WHOI-2000-05

Woods Hole Oceanographic Institution

Knorr 147 Leg V Hydrographic Data Report: Labrador Sea Deep Convection Experiment

by

Sarah Zimmerman
Theresa K. McKee
Robert S. Pickart

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

William M. Smethie

Lamont-Doherty Earth Observatory
Palisades, NY 10964

May 2000

Technical Report

Funding was provided by the Office of Naval Research under Contract No. N00014-97-1-0043.

WHOI-2000-05

Knorr 147 Leg V Hydrographic Data Report: Labrador Sea Deep Convection Experiment

by

Sarah Zimmerman
Theresa K. McKee
Robert S. Pickart
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

William M. Smethie
Lamont-Doherty Earth Observatory
Palisades, NY 10964

May 2000

Technical Report

Funding was provided by the Office of Naval Research under Contract No. N00014-97-1-0043.

Approved for Distribution:

Terrence M. Joyce, Chair

Department of Physical Oceanography

Table of Contents

List of Tables

List of Figures

Knorr 147 Leg V Hydrographic Data Report: Labrador Sea Deep Convection Experiment

Abstract

Between 2 February and 20 March 1997, the first phase of the Labrador Sea Deep Convection Experiment was carried out on *R/V Knorr*, during which 127 hydrographic stations were occupied throughout the Labrador basin. This included five boundary crossings (two on the east and three on the west). Special emphasis was placed on the western portion of the basin where deep convection occurs. Expendable Bathy Thermographs (XBTs) were launched regularly to increase resolution near the boundary and to help optimally place interior stations. Three "to-yo" CTD surveys were conducted, and Langrangian floats were deployed throughout the cruise. Despite extremely difficult working conditions, the cruise was successful in observing deep convection under "classic" wintertime conditions. This report describes the CTD operation and performance and also presents vertical profiles of CTD Potential Temperature, Salinity, and Potential Density (referenced to the surface and 1500 db) plotted versus Depth. Instructions for obtaining the data via anonymous FTP are included in Appendix B.

Introduction

The overall objective of the cruise was to determine the hydrographic structure of the Labrador Sea during active convection. This includes the large-scale water mass structure, the broad circulation, and the characterization of the convective mixed-layers. Additionally, it was our goal to investigate smaller-scale convective events using detailed "to-yo" CTD surveys. Finally, the cruise served as a platform for the deployment of various Lagrangian drifters and measurement of atmospheric variables and air–sea fluxes. Figure 1 shows the locations of the hydrographic stations occupied. The cruise was a resounding success on all counts. Despite very difficult working conditions—including high winds, bitter-cold temperatures, pack ice and icebergs—we were hove-to only 32 hours out of 34 days in the working area. February 1997 was, in fact, colder than normal, and the atmospheric conditions were those of classic Labrador Sea convective forcing. Accordingly, deep convection was observed to 1500 m. In addition to the broad hydrographic coverage, including five boundary crossings, three to-yo CTD surveys were done. The second such to-yo sampled a patch of newly convected water.

This data report describes the CTD operation, including the equipment, techniques and methods, and instrument performance. The overall quality of the hydrographic data set is superb. Included in the report are plots of vertical profiles of potential temperature, salinity, and potential density. To learn more about the cruise, including the float, air–sea flux, and meteorological components, the reader is referred to Pickart, Guest, Dobson, and Bumke: *Knorr* 147 Leg V Cruise Summary: Labrador Sea Convection Experiment (see Appendix B). Pickart (1997) describes the challenging working conditions on the cruise.

1. Instrumentation

1.1 Equipment Configuration and Data Handling Procedure

Three CTDs (Conductivity, Temperature, and Depth profiler) were used on the cruise. Two were EG&G MK-III CTDs: CTD 9 and CTD 12. Each of these had a thermally isolated titanium pressure transducer, a platinum temperature probe with an estimated lag of 150 msec and 240 msec, respectively, and a 3-cm conductivity cell. CTDs 9 and 12 had sampling rates of 23.81 hz and 25.0 hz, respectively. The third CTD used on the cruise was a Falmouth Scientific Instruments (FSI) Integrated CTD: ICTD 1338. This had a thermally isolated titanium pressure transducer, a platinum temperature probe with an estimated lag of 630 msec, and an inductive conductivity sensor. Its sampling rate was 26.0 hz. Oxygen sensors were installed on all CTDs, swapped out and purposefully left off as called for during the cruise.

Table 1 gives time, position, and bottom depth information for each station.

One rosette frame, built at WHOI for reduced drag and weight, was used on the cruise. The frame held twenty-four, 4-liter, WHOI-designed bottles released by an FSI 24-position pylon. Inside the frame were mounted the CTD, a Lowered Acoustic Doppler Current Profiler, and a 10-kHz pinger. The pylon and CTD were controlled by the FSI deck unit, which provided power and commands down the wire to the pylon and forwarded the return information to a dedicated computer.

An alternate setup was used for to-yo stations and shelfbreak stations 20–29 where no bottle data were required. The objective for the to-yo stations was to perform multiple casts while the ship was slowly steaming. To-yo station numbers were kept on separate series (200+, 300+, 400+) to avoid confusion. All the to-yos and the shelfbreak stations 20–29 were performed with CTD 12, secured in its protective cage with a fin attached. The fin kept the CTD from spinning as it was towed. On a few of the casts, two 1.2-liter Niskin bottles were attached to the wire and tripped using a messenger.

Safety was an important issue due to the weather conditions experienced on this cruise. Watchstanders participating in deck work always wore Mustang suits. The deck was regularly shoveled free of excess snow and ice and spread with sand. The CTD package was strapped to a cart that was pulled into the starboard hangar during steaming and pulled out along a track for each station. The heated hangar allowed water sampling to be performed more safely while the ship was underway. Winds, seas and snow made the operation difficult, but with care from the ship's crew and watchstanders the operations were performed without injury.

In both the standard and towed configuration, the CTD packages were attached to the ship's three-conductor CTD-wire. The data was sent in real time from the CTD to the ship's main lab, where it was demodulated by the FSI deck unit and sent to two personal computers running EG&G version 3.0 CTD acquisition software (Oceansoft Acquisition Manual, 1990). One computer provided graphical data to the screen and plotter and a listing output to the printer, while the other

displayed the listing output. Both computers saved the raw, uncalibrated data to disk. The CTD's approach to the ocean bottom was controlled by following the pinger direct and bottom-return signals on the ship-provided PDR. After each station the CTD data were forwarded to another set of personal computers running both EG&G CTD post-processing software and custom-built software from WHOI (Millard and Yang, 1993). Both the downcasts and upcasts of each station were first-differenced, lag-corrected, pressure-sorted, and pressure-centered into 2-db bins for final data quality control and analysis, including fitting to water sample salinity and oxygen results. The downcast, but not the upcast data, received further quality control edits using both WHOI CTD software (see above) and MATLAB-based programs written by the data processor, Sarah Zimmermann. The edits included interpolations over previously-removed spikes in salinity and oxygen.

1.2 Equipment Use And Performance Summary

CTD 9 was used for the first set of stations, but it became clear that the salinity data quality was steadily degrading between stations 6 and 14. ICTD 1338 replaced CTD 9 starting with station 15. Due to the questionable quality of station 14's data, station 15 was occupied at the same location. Station 14 was removed from the data set due to its inferior salinity data. Although there was no visible problem with CTD 9's conductivity sensor, the nature of the problem suggested the cause was a cracked conductivity sensor. The sensor was replaced, and the CTD was later used from stations 48 to 127 with no trace of the salinity problem.

ICTD 1338 was used with success until station 47. On the uptrace of that station there was a sudden failure in the conductivity due to a seawater leak resulting from a failed stem on the redundant temperature thermometer. The stem holds the thermometer in place. The CTD was completely disassembled following station 47 to flush out the salt water and prevent corrosion. It appeared the problem also affected the conductivity in the previous station (46) resulting in less accurate salinities. Initially a second ICTD, ICTD 1344, was made ready for replacing ICTD 1338, but due to a grounding problem resulting in a broken conductivity cell, CTD 9 was put back on the package and used for the remaining stations.

In spite of the above mentioned problems for CTD 9 and ICTD 1338, all stations have been processed to the desired quality of pressure, temperature, and salinity with the exception of station 9 (salinity bad below 1750 db), station 46 (slightly degraded salinity accuracy), and station 47 (slightly degraded salinity accuracy on downtrace, bad uptrace). See Section 3.2 for a summary of salinity accuracies.

There were pylon communication problems during the casts that required close attention to the pylon output messages. Often repeated 'trip' commands were needed to fire bottles and non-standard responses from the pylon had to be dealt with. Close attention to these issues by the watchstanders during the cast provided bottle closures at the requested depths.

The configuration of CTD 12 without the rosette frame worked well, for both the to-yos and the shelfbreak stations 20–29. A few Niskin bottles were attached to the sea cable and used to provide salinity calibration points.

CTD oxygen performance was poor, in large part due to cold air temperature adversely affecting the sensors on deck before deployment and after recovery. CTD oxygen was not a priority for the cruise so during extreme weather the oxygen assembly containing the sensor was physically removed from the CTD. A pass at calibrating the data was performed but only a portion of the stations, 6, 30–34, and 83–118, appeared successful. Table 2 summarizes the overall CTD performance during the cruise.

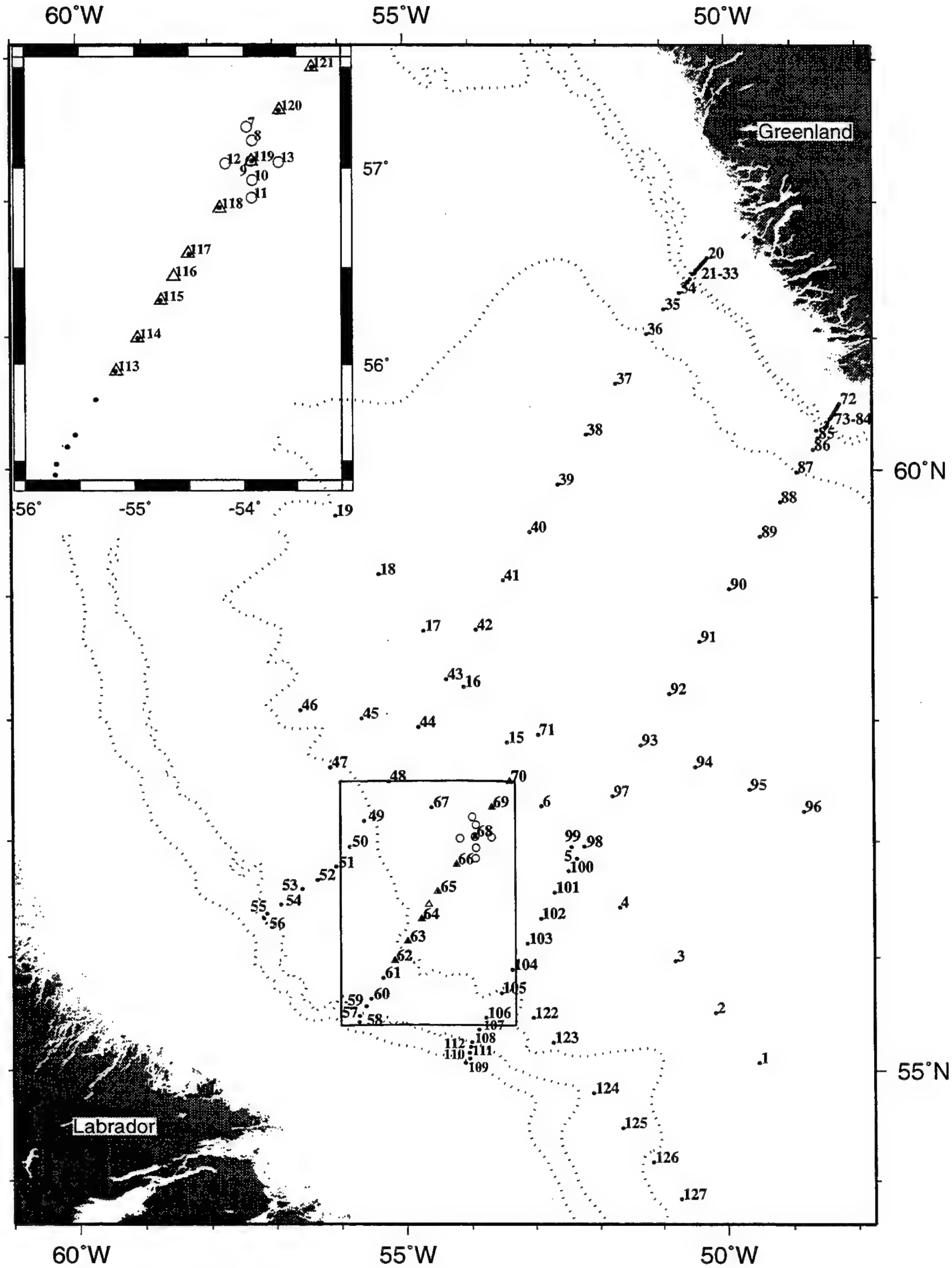


Figure 1: Map showing locations of hydrographic stations taken during *Knorr* 147 leg V. A portion of the central western boundary section was occupied twice (separated by roughly 10 days): stations 57–71 comprise the first occupation (•), and stations 113–121 the second occupation (△, see insert). Stations 7–13 (○, insert) coincided with a small-scale intensive float deployment early in the cruise.

Table 1: Dates, Positions, and Bottom Depths for *Knorr* 147, Leg V Hydrographic Stations

Station Number	Date GMT	Time	Latitude °N	Longitude °W	Corrected Depth m
1	02/08/97	1642	55 04.17	49 31.27	3634
2	02/09/97	0029	55 30.67	50 10.68	3587
3	02/09/97	0851	55 58.13	50 48.15	3590
4	02/09/97	1812	56 25.90	51 40.65	3575
5	02/10/97	0157	56 50.93	52 20.62	3511
6	02/10/97	1110	57 17.40	52 53.20	3446
7	02/11/97	1245	57 12.23	53 58.40	3350
8	02/11/97	1610	57 08.13	53 55.05	3349
9	02/12/97	1639	57 02.05	53 55.62	3332
10	02/12/97	2132	56 56.38	53 55.10	3348
11	02/12/97	2329	56 51.17	53 55.35	3357
12	02/13/97	0353	57 01.37	54 10.10	3327
13	02/13/97	0822	57 01.75	53 40.40	3378
*14	02/13/97	1645	57 48.30	53 26.62	3463
15	02/13/97	2140	57 49.28	53 25.20	3469
16	02/14/97	0446	58 16.47	54 05.37	3430
17	02/14/97	1201	58 43.38	54 42.30	3337
18	02/14/97	1839	59 10.80	55 23.60	3256
19	02/15/97	1451	59 38.52	56 03.25	3077
20	02/16/97	1941	61 35.43	50 15.60	160
21	02/16/97	2043	61 34.40	50 17.35	141
22	02/16/97	2122	61 33.45	50 19.15	135
23	02/16/97	2156	61 32.80	50 20.70	116
24	02/16/97	2235	61 32.12	50 21.53	105
25	02/16/97	2325	61 31.30	50 22.72	115
26	02/16/97	2359	61 30.55	50 24.57	125
27	02/17/97	0029	61 30.12	50 26.05	200
28	02/17/97	0119	61 29.90	50 25.72	199
29	02/17/97	0211	61 28.83	50 26.90	744
30	02/17/97	0412	61 28.40	50 29.15	1036
31	02/17/97	0649	61 26.22	50 31.40	1259
32	02/17/97	0840	61 24.92	50 34.00	2139
33	02/17/97	1105	61 22.98	50 36.98	2788
34	02/17/97	1431	61 20.08	50 41.52	2854
35	02/17/97	1829	61 12.87	50 56.10	2976
36	02/18/97	0000	61 01.68	51 12.95	3026
37	02/18/97	0513	60 39.05	51 42.18	3157
38	02/18/97	1122	60 16.02	52 09.90	3321

*No Data Obtained at This Station

Table 1. Continued

Station Number	Date GMT	Time	Latitude °N	Longitude °W	Corrected Depth m
39	02/18/97	1707	59 53.00	52 36.55	3377
40	02/18/97	2212	59 30.93	53 02.93	3441
41	02/19/97	0321	59 07.88	53 28.13	3355
42	02/19/97	1504	58 43.98	53 54.00	3420
43	02/19/97	2143	58 20.08	54 21.87	3414
44	02/20/97	0357	57 56.85	54 47.80	3385
45	02/20/97	1204	58 00.90	55 39.97	3225
46	02/20/97	1834	58 04.98	56 36.05	3165
47	02/21/97	0053	57 36.92	56 08.88	3001
48	02/21/97	1037	57 30.03	55 15.16	3110
49	02/21/97	1540	57 10.02	55 38.40	3002
50	02/21/97	1956	56 56.83	55 51.53	2923
51	02/21/97	2358	56 46.88	56 04.23	2723
52	02/22/97	0329	56 39.92	56 20.92	2610
53	02/22/97	0640	56 35.37	56 35.11	2437
54	02/22/97	1523	56 27.25	56 26.52	2294
55	02/22/97	1840	56 22.65	57 07.80	1960
56	02/22/97	2107	56 20.18	57 11.15	1803
57	02/23/97	1755	55 29.02	55 43.00	1853
58	02/23/97	2012	55 25.60	55 43.48	1577
59	02/24/97	0515	55 34.30	55 36.92	2234
60	02/24/97	0755	55 38.11	55 32.70	2455
61	02/24/97	1132	55 59.02	55 21.33	2789
62	02/24/97	1614	55 57.93	55 10.77	2945
63	02/24/97	2205	56 08.10	54 58.23	3070
64	02/25/97	0233	56 19.78	54 46.07	3078
65	02/25/97	0725	56 33.95	54 30.07	3185
66	02/25/97	1141	56 48.18	54 13.42	3316
67	02/25/97	1759	57 16.95	54 36.22	3269
68	02/25/97	2334	57 02.03	53 55.43	3357
69	02/26/97	0359	57 17.03	53 40.35	3406
70	02/26/97	0841	57 29.97	53 22.90	3444
71	02/26/97	1413	57 52.97	52 55.98	3507
72	02/26/97	1626	60 30.28	48 14.45	118
73	02/27/97	1758	60 29.13	48 15.78	136
74	02/27/97	1845	60 28.32	48 16.63	139
75	02/27/97	1919	60 27.48	48 17.67	146
76	02/27/97	1957	60 26.53	48 18.98	149
77	02/27/97	2025	60 25.57	48 20.17	174
78	02/27/97	2057	60 24.67	48 21.43	230

Table 1. Continued

Station Number	Date GMT	Time	Latitude °N	Longitude °W	Corrected Depth m
79	02/27/97	2132	60 23.87	48 22.37	486
80	02/27/97	2225	60 23.08	48 23.47	968
81	02/28/97	0030	60 21.75	48 25.15	1440
82	02/28/97	0238	60 20.53	48 26.03	1822
83	02/28/97	0437	60 19.33	48 27.82	2461
84	02/28/97	0721	60 17.95	48 35.77	2800
85	02/28/97	1031	60 14.47	48 34.72	2895
86	02/28/97	1435	60 09.10	48 39.08	2850
87	02/28/97	1730	59 58.90	48 54.57	3017
88	02/28/97	2231	59 44.98	49 09.85	3217
89	03/01/97	0302	59 28.77	49 28.10	3401
90	03/01/97	0852	59 03.57	49 56.67	3467
91	03/01/97	1507	58 38.15	50 24.16	3522
92	03/01/97	2109	58 13.07	50 52.40	3547
93	03/02/97	0322	57 47.78	51 20.15	3611
94	03/02/97	0901	57 37.05	50 28.70	3597
95	03/02/97	1505	57 25.97	49 39.03	3605
96	03/02/97	2114	57 14.85	48 49.12	3581
97	03/03/97	1142	57 22.61	51 46.96	3529
98	03/03/97	2306	56 56.88	52 13.33	3513
99	03/04/97	1404	56 56.85	52 25.45	3500
100	03/04/97	1847	56 44.57	52 28.38	3514
101	03/05/97	0025	56 33.53	52 41.23	3505
102	03/05/97	0620	56 19.98	52 54.23	3514
103	03/05/97	1150	56 06.92	53 06.88	3337
104	03/05/97	1608	55 53.20	53 21.33	3154
105	03/05/97	2001	55 40.95	53 31.53	2989
106	03/06/97	0049	55 27.97	53 46.03	2770
107	03/06/97	0442	55 21.65	53 52.72	2462
108	03/06/97	0825	55 15.10	53 59.85	2017
109	03/06/97	1432	55 04.18	54 05.77	787
110	03/06/97	1557	55 06.38	54 01.57	971
111	03/06/97	1746	55 09.58	54 02.13	1428
112	03/06/97	1937	55 12.47	54 00.82	1689
113	03/07/97	1302	55 57.95	55 10.32	2934
114	03/07/97	1657	56 08.13	54 58.45	3049
115	03/07/97	2255	56 19.88	54 45.48	3066
116	03/08/97	0410	56 27.33	54 38.57	3100
117	03/08/97	0858	56 34.12	54 30.65	3177
118	03/08/97	1452	56 47.98	54 13.12	3311

Table 1. Continued

Station Number	Date GMT	Time	Latitude °N	Longitude °W	Corrected Depth m
119	03/10/97	1443	57 02.00	53 55.57	3340
120	03/10/97	1915	57 17.07	53 39.98	3395
121	03/11/97	0004	57 29.95	53 22.97	3431
122	03/11/97	1839	55 27.90	53 01.63	3119
123	03/11/97	2332	55 14.83	52 43.08	3086
124	03/12/97	1052	54 48.07	52 05.58	2292
125	03/12/97	1511	54 28.92	51 38.87	2795
126	03/12/97	1947	54 10.13	51 09.85	3118
127	03/13/97	0054	53 49.87	50 43.73	3168

Table 2: CTD Performance Summary

Station Number	CTD	Oxygen Sampled (Y/N)	Comments
Section 0			
1–5	9	Y	
6–14	9	Y	• Variable conductivity; data required special editing.
15–18	1338	Y	
200	12	N	• To-yo with CTD 12. One bottle to calibrate salts.
19	1338	Y	
Section 1			
20–29	12	Y	• Shelf stations. No bottles, cannot calibrate oxygen. • Uptrace for 25 discarded
30–36	1338	Y	• Station 36 oxygen sensor failed.
37–47	1338	N	• CTD record layout in calibration file changed (06–2 and 07–1 removed; 16-2 added as placeholder, no added instrument).* • Station 47 CTD failed; bad conductivity on uptrace due to flooding.
48–52	9	N	• New conductivity cell installed on CTD 9 prior to station 48.
53–56	9	Y	
Section 2			
57–71	9	Y	
Section 3			
72–79	9	Y	• Shelf stations: Collected water samples for salinity but not for oxygen.
80–112	9	Y	
Section 4			
113–118	9	Y	
301–305	12	Y	• To-yo with CTD 12. Ten bottles to calibrate salts.
119–121	9	Y	
401–405	12	N	• To-yo with CTD 12
Heading South			
122–127	9	Y	

*Important only if more scaling is done with calibration file.

2. Laboratory Calibrations of CTDs

The pressure, temperature, and conductivity sensors were calibrated by Marshall Swartz at the Woods Hole Oceanographic Institution's CTD calibration laboratory. The pre-cruise calibrations were performed October 20–24 1996. The calibrated CTDs were taken on *R/V Knorr* cruise 147 leg II from November to December. CTD 12 was used only once and CTD 9 just twice on the cruise before being stored until their use on leg V. ICTD 1338 was an exception. It was used as the primary CTD on the November cruise, flown home afterwards for a new temperature sensor, recalibrated and then brought back to the ship.

The post-cruise calibrations were performed May 7–29 1997. The results of the laboratory calibration, the polynomial coefficients, are listed in individual files for each CTD (see Appendix A).

2.1 Method/Calibration Standards

2.1.1 Pressure

The pressure transducer of each CTD was calibrated in a temperature controlled bath to the WHI Ruska Deadweight Tester (DWT) as described by Millard and Yang (1993). The pre- and post-cruise calibration consisted of pressure calibrations at two temperatures, near 0°C and near 30°C. The pressure calibrations at the two temperatures were used to solve for the terms S1 and S2, that correct for both static and dynamic responses of pressure to transducer temperature (J. Toole, personal communication, 1994). For all three CTDs, the pre-cruise calibration slope and 3rd coefficient were used to scale the data, while the bias term was adjusted for each station so pressure read 0 db at the start of each cast (see discussion below of pressure calibrations at sea).

<u>CTD 9</u>

In both sets of calibrations (the 0°C and 30°C baths), the CTD changed between 0 and −0.2 db at 0 db and between 0.4 and 0.5 db at 6000 db. With this small amount of change, there was no need to rescale the data with the post-cruise calibration. The cruise data were scaled with the pre-cruise pressure coefficients.

<u>ICTD 1338</u>

No post-cruise calibration (due to the seawater leak) for comparison with the pre-cruise calibration. The pre-cruise calibration was used to scale the cruise data.

<u>CTD 12</u>

In both sets of calibrations (the 0°C and 30°C baths) the CTD changed between 0.3 and 0.5 db at 0 db and 0.3 db at 6000 db, the average change being a bias shift of 0.4 db. The data were not changed, but were left scaled with the pre-cruise calibration.

2.1.2 Temperature

The CTD sensors were immersed to a minimum of 18 inches in a 700-liter tank of seawater containing the F18/SPRT4070 temperature standard. The calibrations began at 30°C and went down close to 0°C. The output of the temperature standard used for the calibrations was converted to the ITPS-68 scale from the ITS-90 temperature scale following the linear formula described by National Institute of Standards and Technology (NIST) (Mangum and Furukawa, 1990).

<u>CTD 9</u>

The temperature difference was +0.0025 at 0°C and −0.005 at 30°C. This was a large change, though it was apparently due to the pre-cruise calibration and not a shift in the CTD during the cruise. Although there were no problems recorded during the pre-cruise calibration, the results from the pre- to post-cruise calibration do differ by roughly the same amount from the pre-cruise calibration and the CTD's two prior calibrations. The difference between the post-cruise calibration and the prior calibrations was small, 0.0015 at 0°C, between 0.0005 and 0.001 at 30°C. This prior calibration was performed in April 1996, six months before the pre-cruise calibration. The cruise data were rescaled with the post-cruise calibration.

<u>ICTD 1338</u>

No post-cruise calibration for comparison. The pre-cruise calibration was used to scale the cruise data.

<u>CTD 12</u>

The temperature difference was very small, 0 at 0°C, −0.0008 at 10°C and 0.002 at 30°C. The cruise data were left as they were scaled with the pre-cruise calibration.

2.1.3 Conductivity

Bottle salinities were drawn during the temperature calibration, five samples at each temperature. These values were then converted to conductivity and compared to the values read by the CTD at the different temperatures (Millard and Yang, 1993). However, the laboratory calibration served only as a check for the CTD conductivity since the cruise data were scaled using calibrations to the bottle salinities collected at sea (see below).

<u>CTD 9</u>

The sensor was replaced after station 14. Comparison of the pre-cruise calibration to station 5, showed the calibration differed from +0.006 to −0.006 mmho over the range 20 to 55 mmho. The post-cruise calibration differed from 0 to −0.004 mmho over 20–55 mmho with station 127's calibration. The change between the pre- and post-cruise calibrations (different sensors) was −0.02 to −0.08 mmho from 20 to 55 mmho, a large change expected when a new sensor has been installed. There was a fairly close agreement however between the laboratory and appropriate at-sea calibrations.

ICTD 1338

No post-cruise calibration data were available for comparison.

CTD 12

The conductivity difference was 0.005 to 0.01 over the range 20 to 60 mmho. The calibration used at sea however was an additional 0.005 to 0.015 above the post-cruise calibration.

3. At-Sea Calibrations of CTDs

3.1 Method/Calibration Standards

3.1.1 Pressure

The pressure of the CTD at the sea surface was recorded at the beginning of each station. A correction was applied to the pressure bias coefficient to bring the pressure to 0 db. The amount of correction varied per CTD station, often by 0.1 db or less between stations. Over the cruise, the maximum difference between the pre-cruise calibration and the corrected pressure bias was $+0.7/-1.2$ db for CTD 9, $\pm$ 1.2 db for ICTD 1338, and +2.0 db for CTD 12.

3.1.2 Temperature

The temperature lag for each CTD was checked at the start of the cruise by comparing density reversals in potential temperature versus salinity plots using station data (Giles and McDonald, 1986). No temperature spikes were found in the 2-db-centered data, hence a list of temperature interpolations was not created.

3.1.3 Conductivity/Salinity

The CTD conductivity sensor data were fit to the water sample conductivity as described by Millard and Yang, (1993). First, all stations were fit as a single large group then divided into sections where there was a noticeable shift in the sensor. These groups were fit for new slopes, keeping the bias constant when possible. Otherwise, a fit was made to both new bias and slopes. If closer inspection of the CTD and water sample salinity data revealed a shape in the residuals, 0.001 to 0.002 psu, the coefficients for thermal and pressure conductivity cell deformation were altered to remove the shape. The same changes to the cell deformation coefficients were made for all the stations taken with a particular CTD unless there was a reason for the CTD to behave differently between stations, such as a failing sensor. While these terms are intended to address cell physics, adjusting them can also correct for issues within the CTD electronics.

3.1.4 Oxygen

The CTD oxygen sensor downtrace variables were fit to water sample oxygen data to determine the six parameters of the oxygen algorithm (Millard and Yang, 1993). As with conductivity, all stations were fit first as one group, and then divided into sections where shifts in the behavior of the sensor were noted. The edit factor was changed from 2.8 to 2.0 standard deviations as necessary to cull for valid data.

3.2 Conductivity Sensor Performance/Fitting Problems and Solutions

CTD 9

CTD 9 was used for stations 1–14 and 48–127. CTD 9's conductivity sensor was replaced after station 14. Stations 7–14 were affected by the slow degradation of the conductivity sensor prior to its replacement. The problem was evident from a shift in the CTD salinity between down- and upcasts and from station to station. It was necessary to fit the downcast to the bottle salts and then fit separately the upcast to the bottle salts for each station (stations 7–14). Station 9 only had bottles only from 0 to 1750 db. The station was fit to the bottles that calibrated the top 1750 db. The data below 1750 db were set to −9.000, and the quality word changed to 4 (bad). Station 14 did not fit correctly to the bottles and was discarded from the data set. No information was lost by removing station 14 since station 15 was performed at the same location.

Use of the post-cruise temperature calibration for CTD 9 led to a recalibration of the CTD salinities (stations 1 to 14, 48 to 127). To correct for a pressure-dependent shape, CTD 9 conductivity cell correction terms for physical deformation due to temperature (α) and pressure (β) had been set to 0 at sea. Post-cruise, with the new temperature calibration, α was set back to its nominal value of -6.5×10^{-6} and β was set to 0.75×10^{-8}, half of β's nominal value of 1.5×10^{-8}.

ICTD 1338

ICTD 1338 was used for stations 15–19 and 30–47. Its conductivity cell stopped working on the upcast of station 47 due to a seawater leak resulting from a failed stem holding the redundant temperature thermometer. Station 46 CTD conductivity appeared to be affected by the leak as well. Station 46 was fit on its own to its bottle data but a pressure-dependent salinity was still evident. As a result, CTD salinity was 0.005 psu high in the shallow water and 0.005 psu low in the bottom water. The 0.005 psu difference was too large an error to correct for with the α and β terms, so no change was made. It was also necessary to fit station 47 independently to its bottle data. Station 47's downcast salinity was fit to the bottle data, and the bottle file's temperature and CTD salinity data were replaced with the downtrace information. The standard deviation of the difference between station 47's scaled CTD record and water sample data was 0.004 psu.

CTD 12

CTD 12 was used for shelf stations 20–29 and to-yo stations 200, 301–305 and 401–405. Conductivity for CTD 12 was calibrated using one bottle from the 200 series, which was taken after station 18 and ten bottles (two per station at the same depth) from the 300 series which was performed after station 118. The calibration from the first bottle held for the 300 series. The standard deviation of the difference between the scaled CTD data and the water samples for the 300 series was 0.0013. The calibration was made by holding the bias from the pre-cruise calibration and adjusting the slope. It is impressive that the calibration did not shift from the to-yo at the beginning of the cruise to the to-yos near the end. The to-yo calibration also was used to scale the shelf stations, but because there is a much larger salinity range on the shelf, the overall accuracy of the salinity on the shelf cannot be calculated unambiguously.

3.2.1 Error Estimates

The standard deviation was calculated between the water sample salinities and the CTD salinities, excluding stations 14, 46, CTD 12, any bottle marked bad or questionable, and differences over ±0.01. The data between 500 db and the bottom had a standard deviation of 0.0015, the data from 0–500 db had a standard deviation of 0.0039, and the full profile had a standard deviation of 0.0025. The standard deviation of CTD 12's salinity residuals in the 300+ series is 0.0013 psu; although these residuals are tight, the overall accuracy may not be quite as good due to the limited range of the salinity from the bottles compared to the salinity range of the CTD. For the shelf stations 20–29, which have a much larger range than the bottle salinities, the accuracy is estimated to be .01 psu. Station 46 is ±0.005 psu. Station 47 is ±0.004 psu on the downtrace and the uptrace profile was removed from the data set. Station 14 was also removed from the data set.

The CTD downtrace overlaid with water sample salinities on a pressure or potential temperature axis occasionally did not agree, particularly with stations 112 and 117. Adding the CTD uptrace to the plot, however, confirmed that the seawater profile often changed between the down- and uptrace, with the uptrace CTD in good agreement with the uptrace bottle salinities. These changes were indicative of the small-scale spatial structure during active convection. Because the uptrace CTD data contained information unique from the downtrace, the uptrace data received the basic processing and reduction steps into 2 db-averaged profiles, steps which are not normally taken with uptrace data. The spikes not caught by the basic editing have not been removed, which makes it a noisier data set than the downtrace data set.

3.3 Oxygen Sensor Performance/Fitting Problems and Solutions

CTD oxygen performance was poor, in large part due to the cold air temperature the sensors were exposed to on deck before and after deployment. One sensor membrane was visibly torn due to ice formation around the membrane, and it is suspected that similar problems may have affected the other sensors. Another problem could be due to a larger than normal error associated with fitting the downtrace CTD oxygen to the uptrace water samples. The salinity data showed that

it was not uncommon for the downtrace profile to differ from the uptrace profile (see above). The downtrace CTD oxygen may not have matched the uptrace oxygen which would have resulted in poorer fitting results. Successfully gathered and calibrated CTD oxygen data were not a priority for the cruise, so during the extreme weather the oxygen assembly was physically removed from the CTD. A first pass at calibration was performed on the CTD oxygen data which was sometimes successful, sometimes not. The stations that appeared successful were 6, 30–34 and 83–118. Table 3 summarizes the CTD Oxygen performance.

Table 3: Summary of CTDs With and Without an Oxygen Sensor Attachment

Station Number	CTD	Oxygen Sampled (Y/N)	Comments
1–14	9	Y	
15–19	1338	Y	
20–29	12	Y	• Shelf stations. No oxygen samples taken.
30–36	1338	Y	• Station 36 oxygen sensor failed.
37–47	1338	N	• CTD record layout in calibration file changed (06–2, 07–1 removed and 16-2 added as placeholder, no added instrument).* • Station 47 CTD failed; bad conductivity on uptrace due to flooding.
48–52	9	N	
53–71	9	Y	
72–79	9	Y	• Shelf stations. No oxygen samples taken.
80–118	9	Y	
301–305	12	Y	• To-yo with CTD 12
119–121	9	Y	
401–405	12	N	• To-yo with CTD 12
122–127	9	Y	

*Important only if more scaling is done with calibration file.

4. Data Quality Control

4.1 2 db-Averaged CTD Downtrace Data

Although the CTD was collecting data as it entered the water at the start of the cast, salinity spikes due to bubbles from entrainment and wave action often required removing data from the top 1–7 m. Upon deployment the CTD was immediately lowered to 5–10 m, the operator then waited for the sensors to respond well before proceeding with the lowering. For safety reasons the CTD was not raised back up to the surface after the initial deployment to 5 m. The uptrace, however, comes much nearer to the surface before the conductivity is compromised from air or air bubbles. Spikes in the 2 db-averaged downcast profiles in salinity and oxygen were removed and then interpolated

over. No spikes were found in temperature. If the spike in the data occurred at the start or end of the station, it was removed or written over with the last good observation. The quality word in the last column of the downcast data files (*.CTD) was adjusted to reflect the change (6 indicates interpolation, 4 indicates bad data). All edits performed on the downtrace profiles were listed in the SALTINT.DOC and OXYINT.DOC files (see Appendix A).

4.2 2 db-Averaged CTD Uptrace Data

The data received the basic processing and data reduction steps but were not de-spiked. Generally the salinity was good up to the 3-db point, but the 1-db point was incorrect due to averaging the air interface in with the seawater data. The questionable or bad 1- and 3-db points have not been removed from the uptrace data files (*.PRS).

4.3 Water Sample Data

The water sample salinity and oxygen quality were carefully reviewed at sea. The quality word for each observation was set to 2 if the observation was good, 3 if it was questionable and 4 if it was bad. The CTD data in the water sample file have been scaled with the proper calibrations but have not been quality edited. The CTD quality words have been left as 3s.

5. Additional Data Taken

Additional data were gathered on this cruise that are not presented in this report, including "to-yo" CTD surveys and Lowered Acoustic Doppler Current Meter profiling data. For more information consult Pickart, Guest, Dobson, Bumke: *Knorr* 147 Leg V Cruise Summary: Labrador Sea Convection Experiment (available by contacting tmckee@whoi.edu and at http://www.whoi.edu/science/po/people/pickartgroup/index.html).

5.1 Chlorofluorocarbon Data

Chlorofluorocarbons (CFCs) 11, 12, and 113 were measured on board at 45 stations by Guy Mathieu of Lamont-Doherty Earth Observatory. Samples were drawn from the Niskin bottles into glass syringes which were stored in a clean seawater bath until analysis within 12 hours of collection. A total of 890 samples were analyzed. Air samples were also analyzed at various locations along the cruise track.

The CFC analyses were made using a Shamadzu 8A gas chromatograph with an electron capture detector interfaced to an automated gas extraction and trapping system. CFCs were removed from seawater by sparging with ultrapure nitrogen and trapped on Unibeads 2s at −65°C. The trap was heated to 100°C and the CFCs flushed into the gas chromatograph. The CFCs were separated from each other and other compounds with a combination of a 3-foot precolumn packed with Porasil B, a 5-foot main column packed with Carbograph 1AC and a 3-inch post column packed with Molecular Sieve 5A. All chromatographic columns were 1/8 inch-diameter stainless steel and ultrapure nitrogen was used as the carrier gas. The precision of the measurements determined from the analysis of duplicate samples was 0.5% for CFC-11, 0.7% for CFC-12, and 1.6% for CFC-113.

6. Description of Plots

Figures 2–128 present downcast vertical profiles of CTD data. Potential Temperature, Salinity, and Potential Density referenced to the surface and 1500 db are plotted versus Depth for each station. For all stations, except 20–30 and 72–79 which are relatively shallow, density profiles are displayed subsampled to 20 db to improve the readability of the plot. The station data are presented in numerical order, not by section. Plots were generated using MATLAB. No data are displayed for station 14, since it was discarded. For station 9, salinity was bad below 1750 db; therefore all properties are truncated at that level.

A. Descriptions of Water Sample and CTD Final-Processed Files

Data Files

KB47.SEA contains bottle data for the entire cruise. All stations were appended together into a single file, containing CTD and water sample information for each bottle stop. The quality word in the last column contains quality information for the bottle and water samples only, not for the CTD data.

Note: For the files listed below, station number should be substituted for the ###.

KB47D###.CTD are the 2 db-averaged, downtrace CTD profiles. Spikes have been removed and interpolations performed as necessary. These edits are listed in the files SALTINT.DOC and OXYINT.DOC. One format was used for all of the station files.

KB47U###.PRS are the 2 db-averaged, uptrace CTD profiles. They have not received any editing beyond the typical first-pass editing performed to the raw binary data. Spikes not caught in the initial at-sea editing are still present. In addition, stations 37–47, where the oxygen assembly was removed and the record layout was changed, do not have a column for oxygen. (Due to sensor problems, there are no uptraces for stations 25 and 47)

KB47.SUM is the station summary file. The positions and times of all stations are recorded in this file. For each station 24 bottles are listed, which is the default entry only, indicating the number of bottles possible per station and not the actual number tripped.

Documentation Files

General

KB47PROC.DOC contains processing notes, lists of stations with specific processing needs.
SALT.DOC lists CTD conductivity fitting results.
SALTINT.DOC lists the interpolations and edits made to the salinity data.
OXY.DOC lists CTD oxygen fitting results.
OXYINT.DOC lists the interpolations and edits made to the oxygen data.

Calibration Coefficients Used to Scale Data

CALPR.DAT lists the pressure coefficients.
CALCODN.DAT lists the conductivity coefficients used to scale the downtrace.
CALCOUP.DAT lists the conductivity coefficients used to scale the uptrace.
CALOX.DAT lists the oxygen current coefficients.

Laboratory Calibrations

KN47C09.DOC CTD 9 pre- and post-cruise calibrations.
KN47C12.DOC CTD 12 pre- and post-cruise calibrations.
KN47C38.DOC ICTD 1338 pre-cruise calibration. No post-cruise calibration.

B. Directions for Obtaining the Data

Data files can be obtained by visiting the Pickart website at http://www.whoi.edu/science/po/people/pickartgroup/index.html).

Documentation files are in-house documents and are not on the FTP site. These files and copies of the cruise summary can be made available by e-mail request to **tmckee@whoi.edu**.

Acknowledgments

We are extremely indebted to Captain A. D. Colburn and the crew of the Research Vessel *Knorr* for their hard work and dedication in making this field program successful. From the moment we left the dock to the steam back home, the cruise was a constant series of challenges. Each of these challenges was met with professionalism, enthusiasm, and a strong desire to realize the scientific objectives. Whether it was pounding ice off the decks of the ship, navigating through white-out conditions, or maintaining stations near the edge of the pack ice, the crew tackled each test, always maintaining the utmost safety and caution.

This was one of the most difficult cruises ever undertaken by a Woods Hole Oceanographic Institution vessel. It was also a striking example of how the makeup of a vessel and the dedication of its crew can impact the success of an experiment.

We are grateful to Veta Green for preparing the final drafts of this report. Barbara Gaffron and Anne-Marie Michael were responsible for technical editing and final formatting.

Funding for this experiment was provided by the Office of Naval Research through contract N00014-97-1-0043.

References

General Oceanics Oceansoft Mark IIIC/SCTD Acquisition Software Manual, 1990. P/N Manul 10239, February, 1990, Miami, FL, 97 pp.

Giles, A. B., and T. J. McDonald, 1986. Two methods for the reduction of salinity spiking of CTDs. *Deep-Sea Research*, **33**, 1253–1274.

Knapp, G. P., M. C. Stalcup, and R. J. Stanley, 1990. Automated oxygen titration and salinity determination. *Woods Hole Oceanographic Institution Technical Report No. WHOI-90-35*, 25 pp.

Mangum, B. W., and G. T. Furukawa, 1990. Guidelines for Realizing the International Temperature Scale of 1990 (ITS-90). National Institute of Standards and Technology, NIST Technical Notes 1265, ~10 pp.

Millard, R. C., and K. Yang, 1993. CTD calibration and processing methods used at Woods Hole Oceanographic Institution. *Woods Hole Oceanographic Technical Report No. WHOI-93-44*, 96 pp.

Owens, W. B., and R. C. Millard, Jr., 1985. A new algorithm for CTD oxygen calibrations. *Journal of Physical Oceanography*, **15**, 621–631.

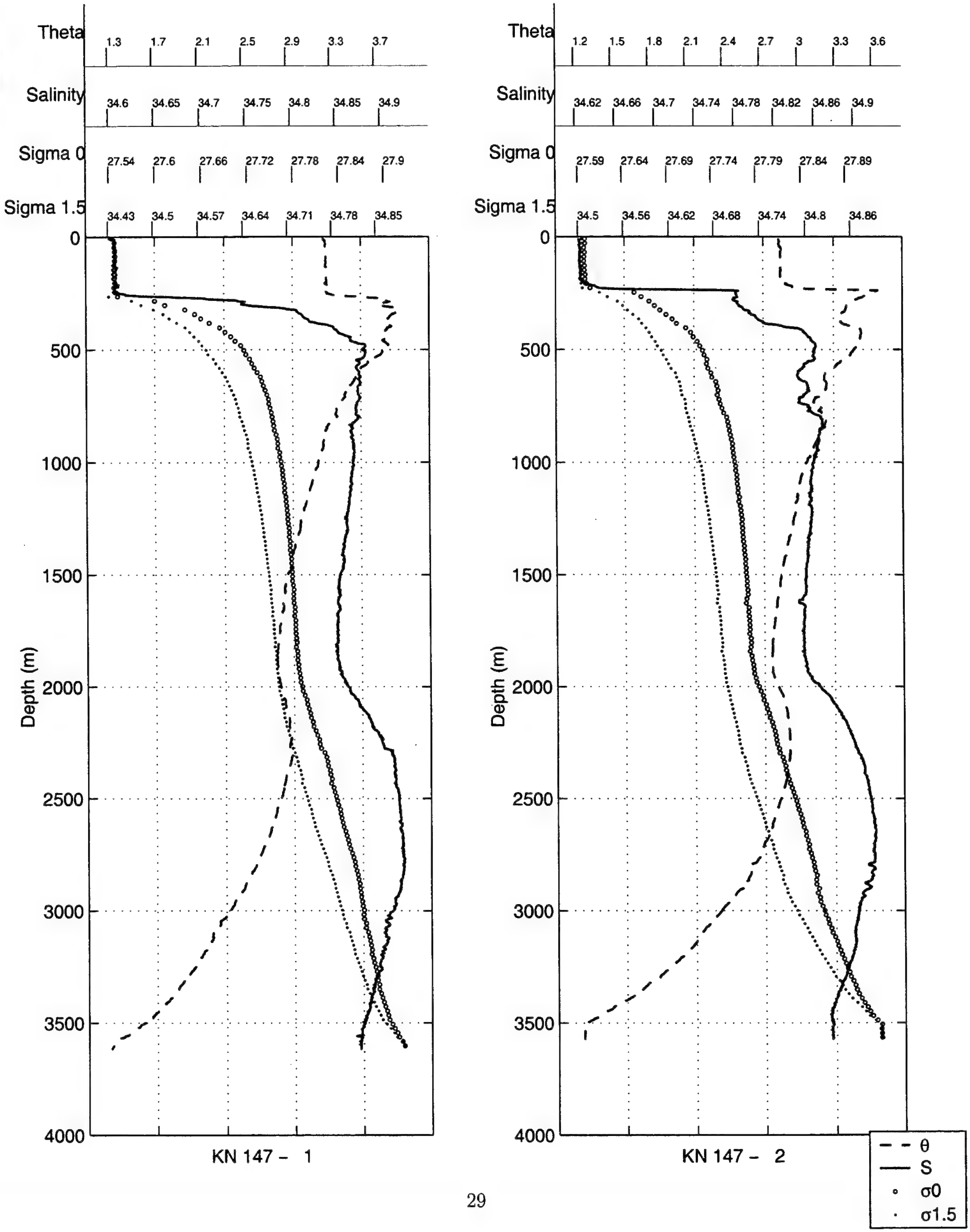
Pickart, R. S., 1997. Adventure in the Labrador Sea: A wintertime cruise to the North Atlantic. *Oceanus*, **40**, 18–24.

RFA-300 Rapid Flow Analyzer Operation Manual, Preliminary, 1985. Alpkem Corporation, Clackamas, Oregon. Looseleaf binder, unnumbered pages.

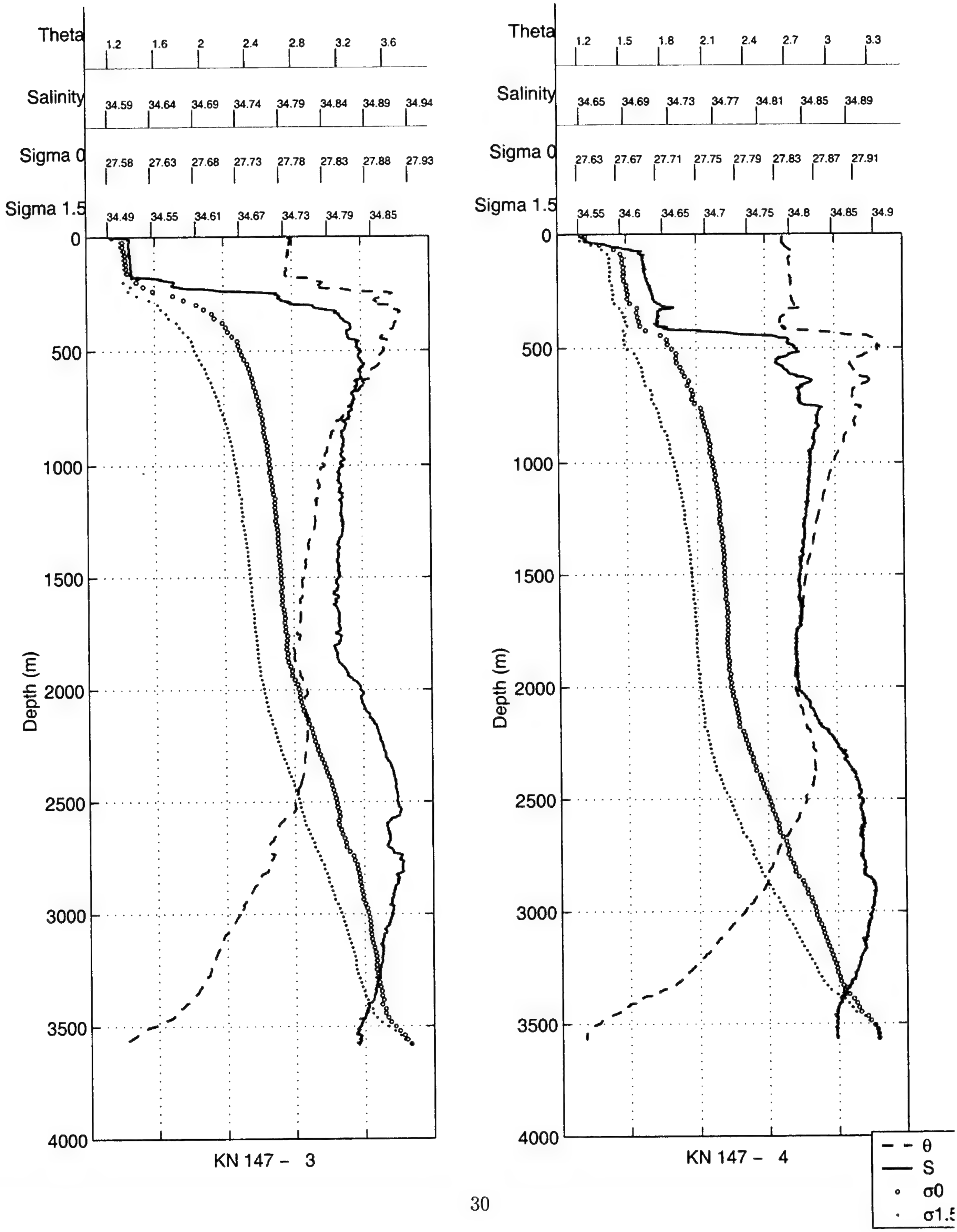
Toole, J. M., G. Bond, and R. C. Millard, 1993. Implementation of a titanium strain-gauge pressure transducer for CTD applications. *Deep-Sea Research*, **40**, 1009–1021.

Data Presentation

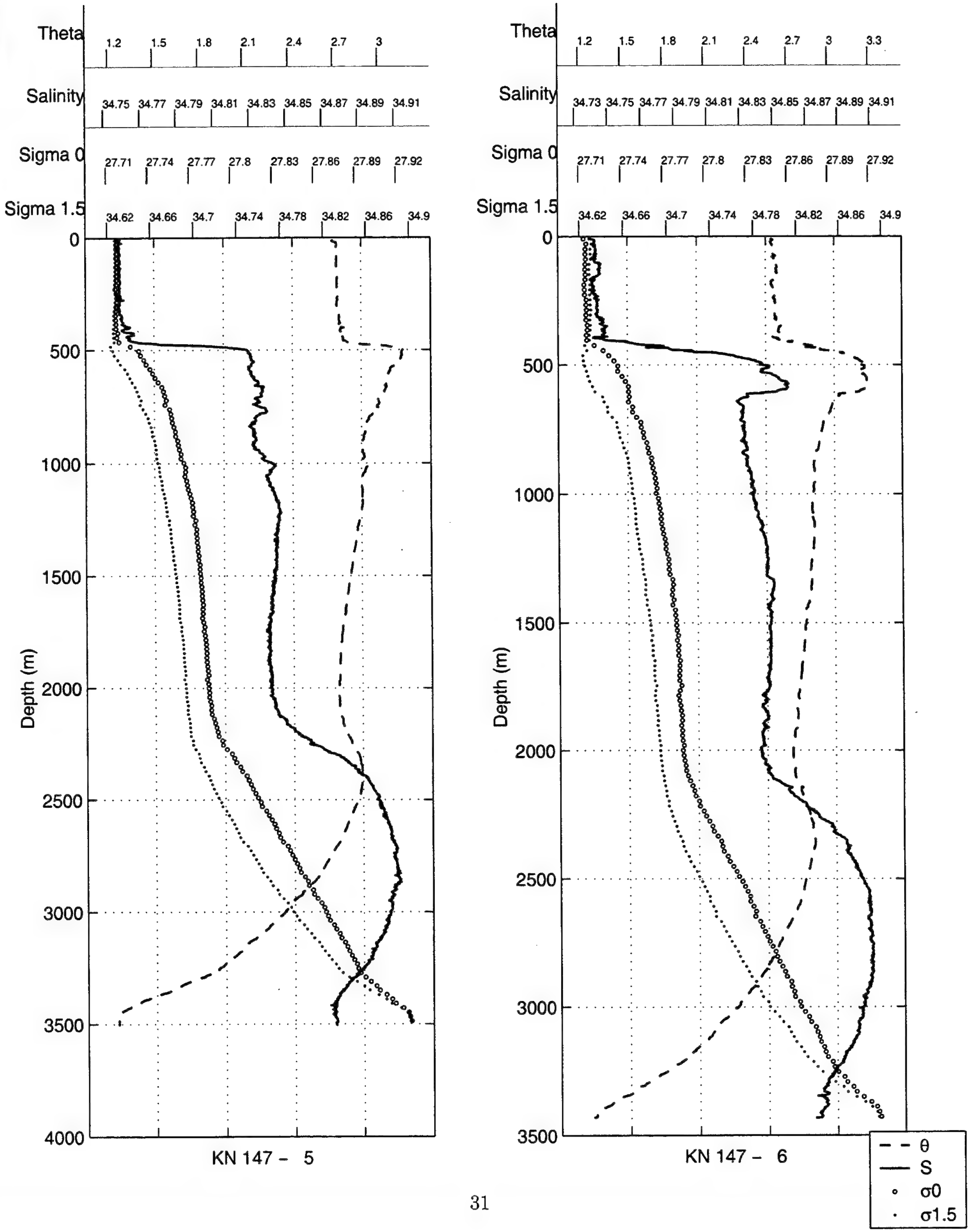
Vertical Profiles for Stations 1–127

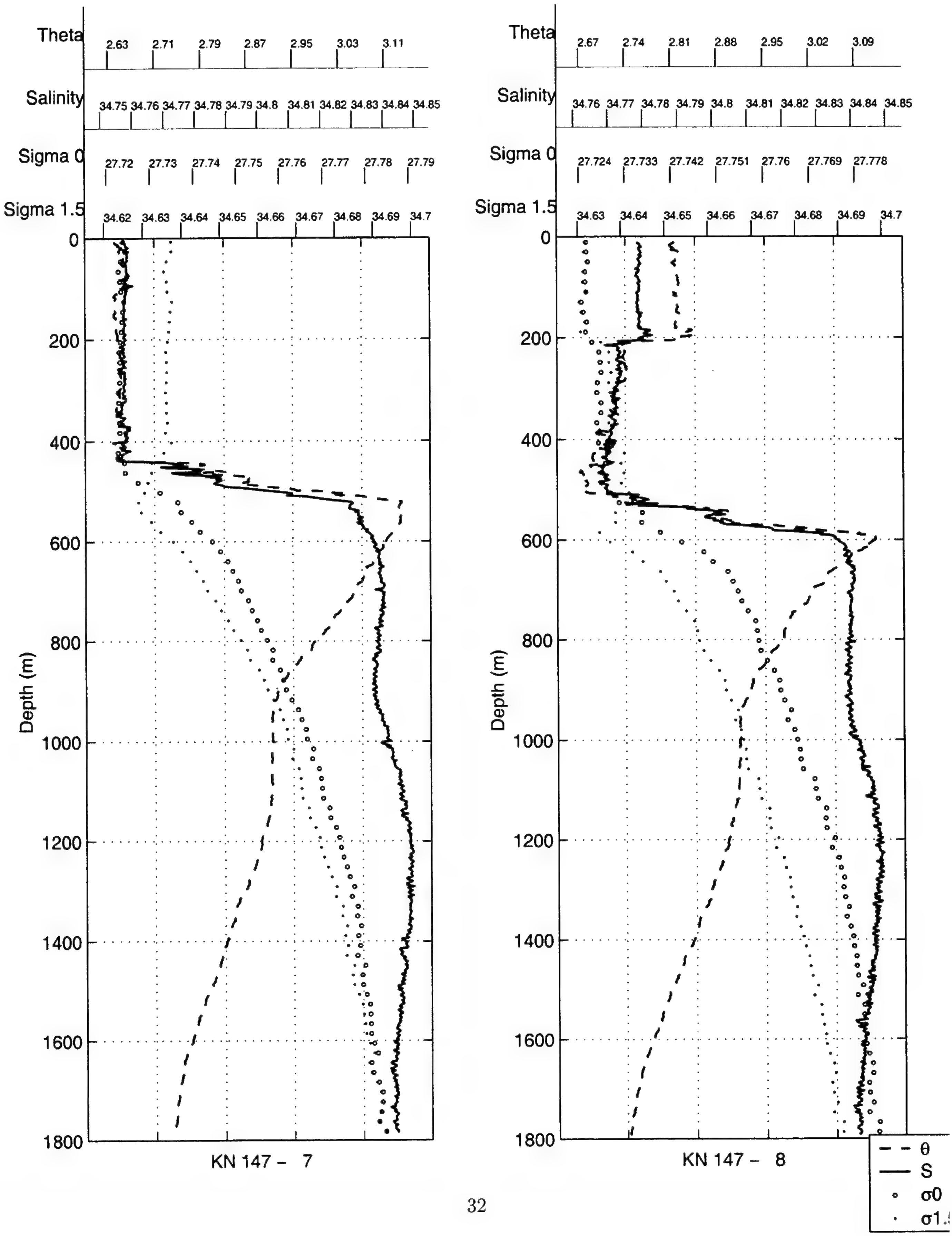


Theta
1.3
1.7
2.1
2.5
2.9
3.3
3.7
Salinity
34.6
34.65
34.7
34.75
34.8
34.85
34.9
Sigma 0
27.54
27.6
27.66
27.72
27.78
27.84
27.9
Sigma 1.5
34.43
34.5
34.57
34.64
34.71
34.78
34.85
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
4000
KN 147 - 1
Theta
1.2
1.5
1.8
2.1
2.4
2.7
3
3.3
3.6
Salinity
34.62
34.66
34.7
34.74
34.78
34.82
34.86
34.9
Sigma 0
27.59
27.64
27.69
27.74
27.79
27.84
27.89
Sigma 1.5
34.5
34.56
34.62
34.68
34.74
34.8
34.86
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
4000
KN 147 - 2
θ
S
σ0
σ1.5

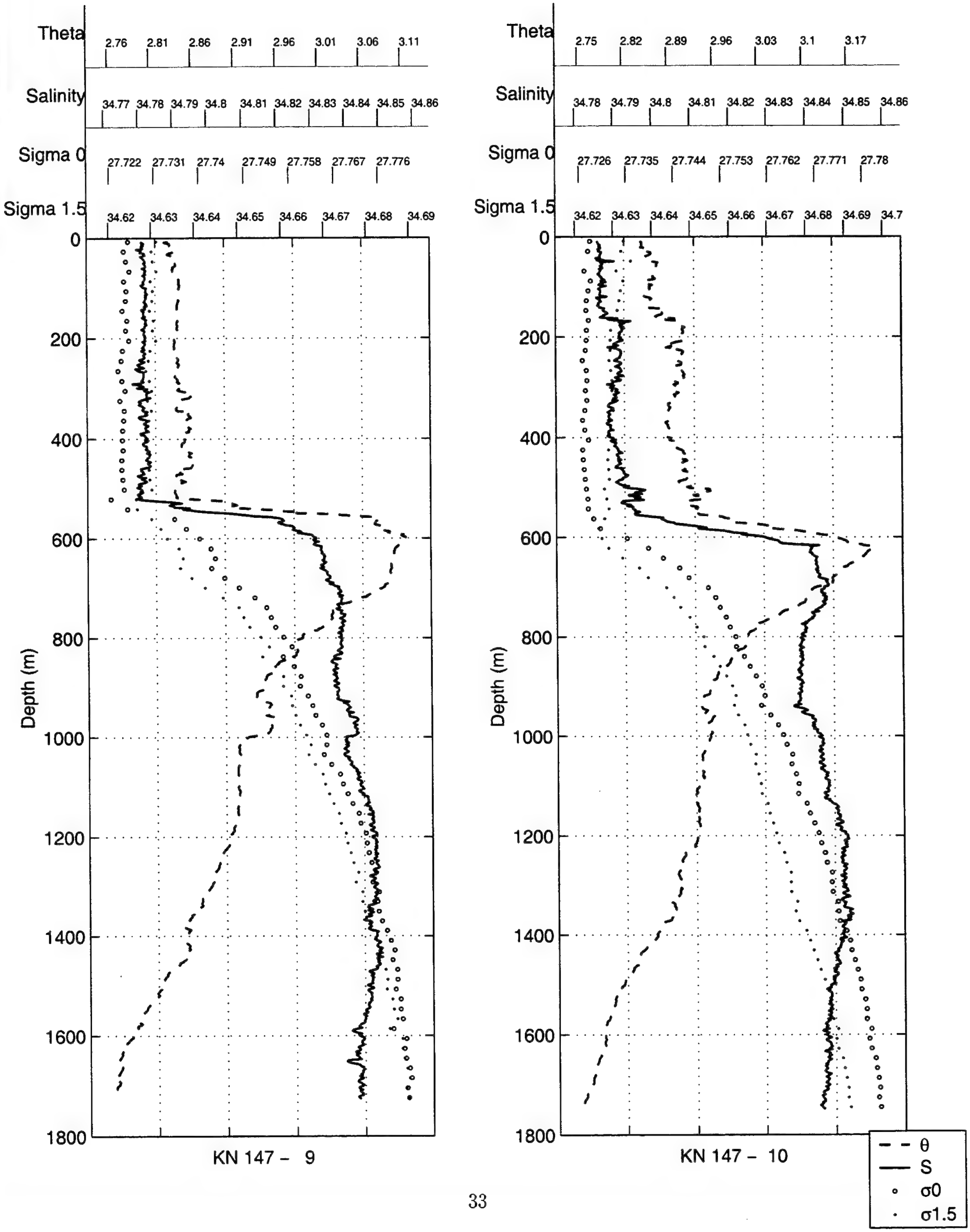


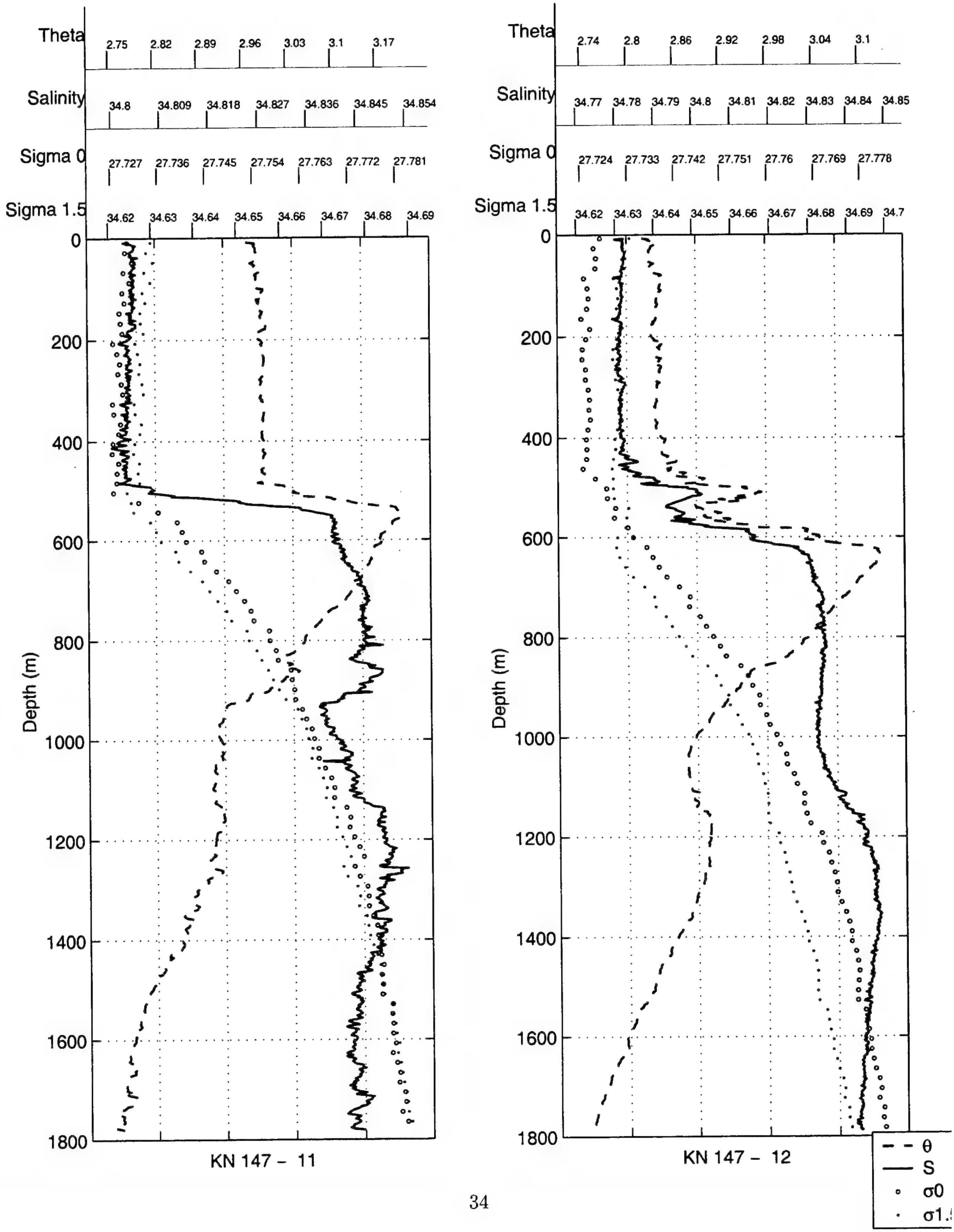
Theta
1.2 1.6 2 2.4 2.8 3.2 3.6
Salinity
34.59 34.64 34.69 34.74 34.79 34.84 34.89 34.94
Sigma 0
27.58 27.63 27.68 27.73 27.78 27.83 27.88 27.93
Sigma 1.5
34.49 34.55 34.61 34.67 34.73 34.79 34.85
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
4000
KN 147 - 3
Theta
1.2 1.5 1.8 2.1 2.4 2.7 3 3.3
Salinity
34.65 34.69 34.73 34.77 34.81 34.85 34.89
Sigma 0
27.63 27.67 27.71 27.75 27.79 27.83 27.87 27.91
Sigma 1.5
34.55 34.6 34.65 34.7 34.75 34.8 34.85 34.9
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
4000
KN 147 - 4
θ
S
σ0
σ1.5

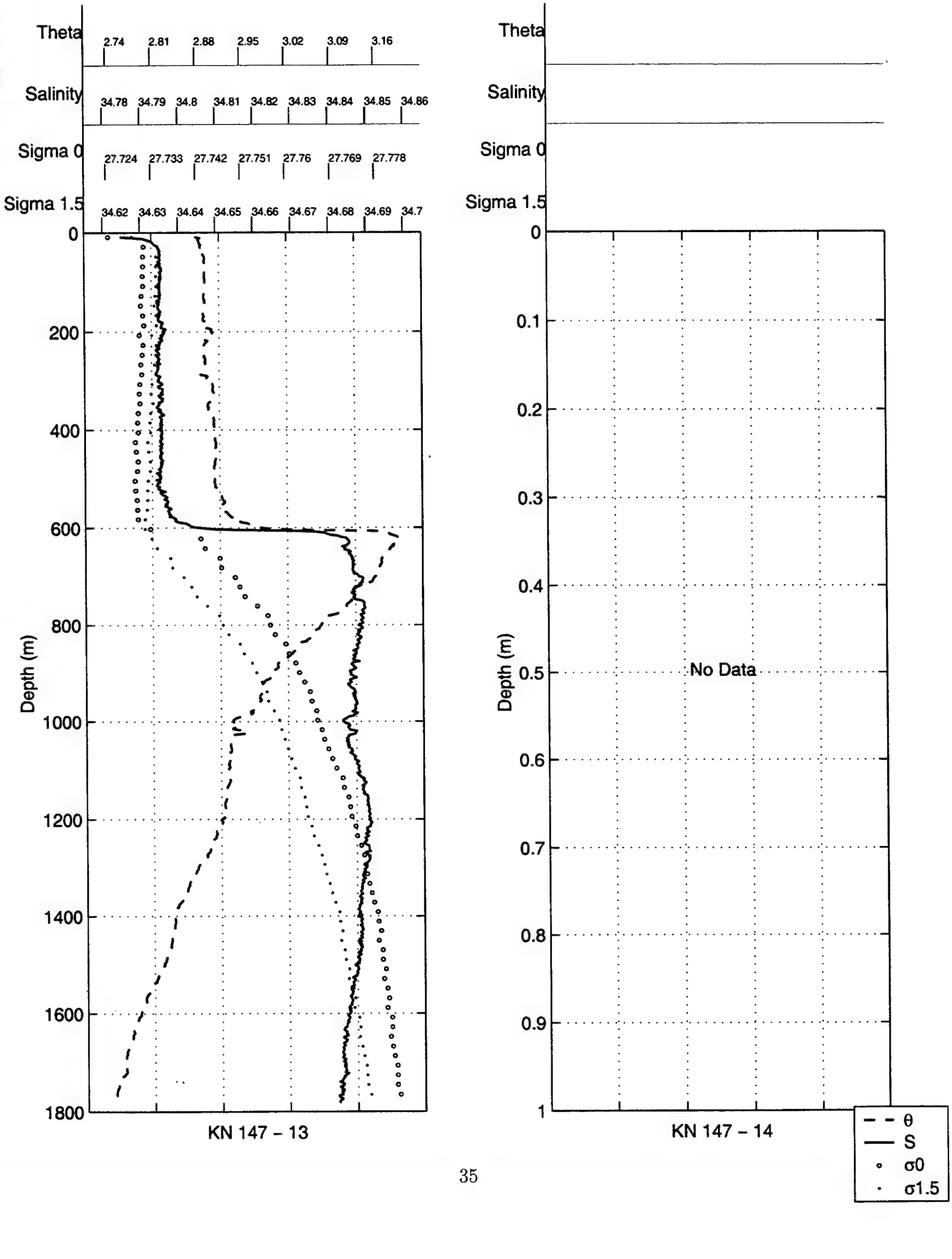

Theta
1.2
1.5
1.8
2.1
2.4
2.7
3
Salinity
34.75
34.77
34.79
34.81
34.83
34.85
34.87
34.89
34.91
Sigma 0
27.71
27.74
27.77
27.8
27.83
27.86
27.89
27.92
Sigma 1.5
34.62
34.66
34.7
34.74
34.78
34.82
34.86
34.9
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
4000
KN 147 - 5
Theta
1.2
1.5
1.8
2.1
2.4
2.7
3
3.3
Salinity
34.73
34.75
34.77
34.79
34.81
34.83
34.85
34.87
34.89
34.91
Sigma 0
27.71
27.74
27.77
27.8
27.83
27.86
27.89
27.92
Sigma 1.5
34.62
34.66
34.7
34.74
34.78
34.82
34.86
34.9
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
KN 147 - 6
θ
S
σ0
σ1.5

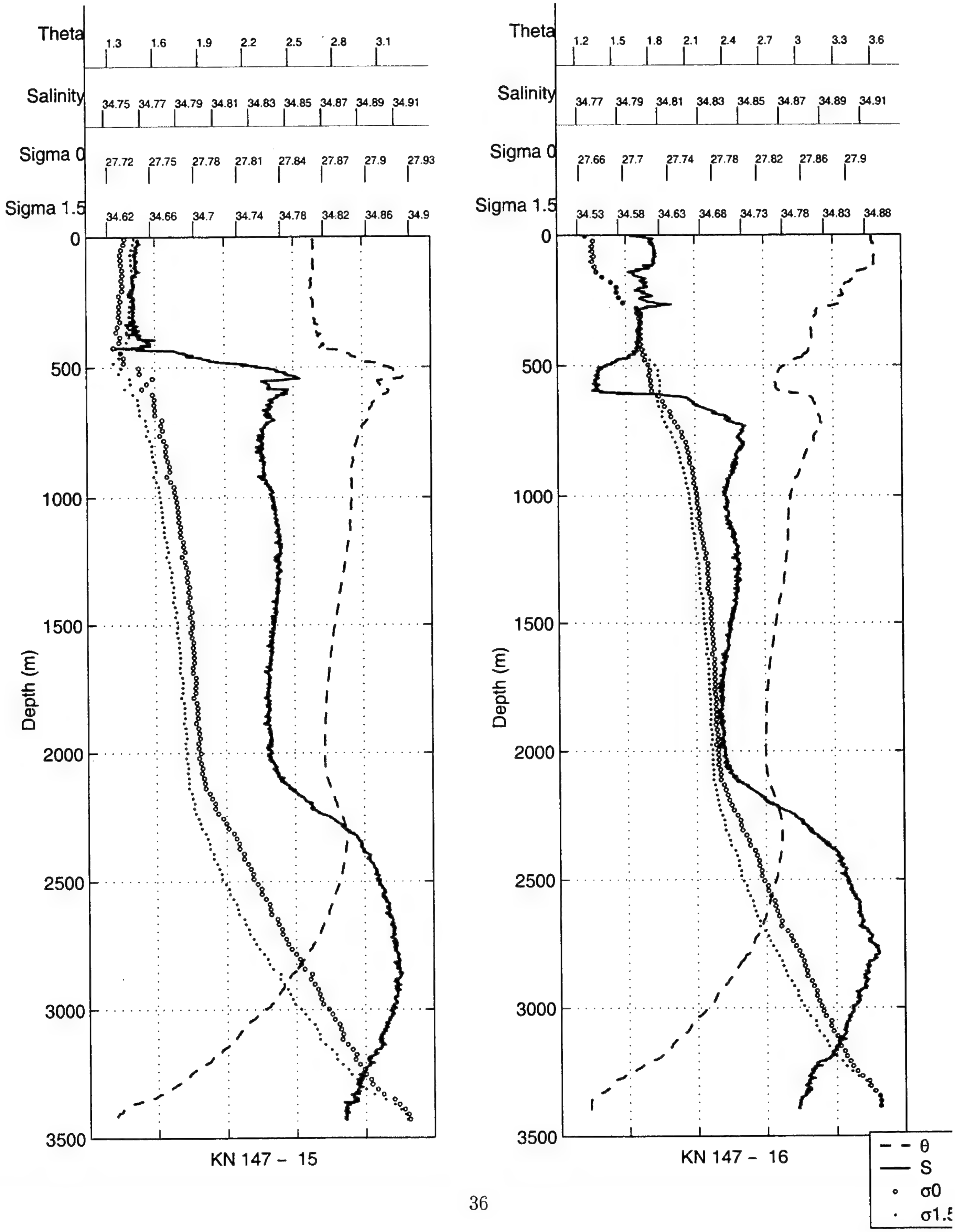


Theta
2.63
2.71
2.79
2.87
2.95
3.03
3.11
Salinity
34.75 34.76 34.77 34.78 34.79 34.8 34.81 34.82 34.83 34.84 34.85
Sigma 0
27.72 27.73 27.74 27.75 27.76 27.77 27.78 27.79
Sigma 1.5
34.62 34.63 34.64 34.65 34.66 34.67 34.68 34.69 34.7
Depth (m)
0
200
400
600
800
1000
1200
1400
1600
1800
KN 147 - 7
Theta
2.67 2.74 2.81 2.88 2.95 3.02 3.09
Salinity
34.76 34.77 34.78 34.79 34.8 34.81 34.82 34.83 34.84 34.85
Sigma 0
27.724 27.733 27.742 27.751 27.76 27.769 27.778
Sigma 1.5
34.63 34.64 34.65 34.66 34.67 34.68 34.69 34.7
KN 147 - 8
θ
S
σ0

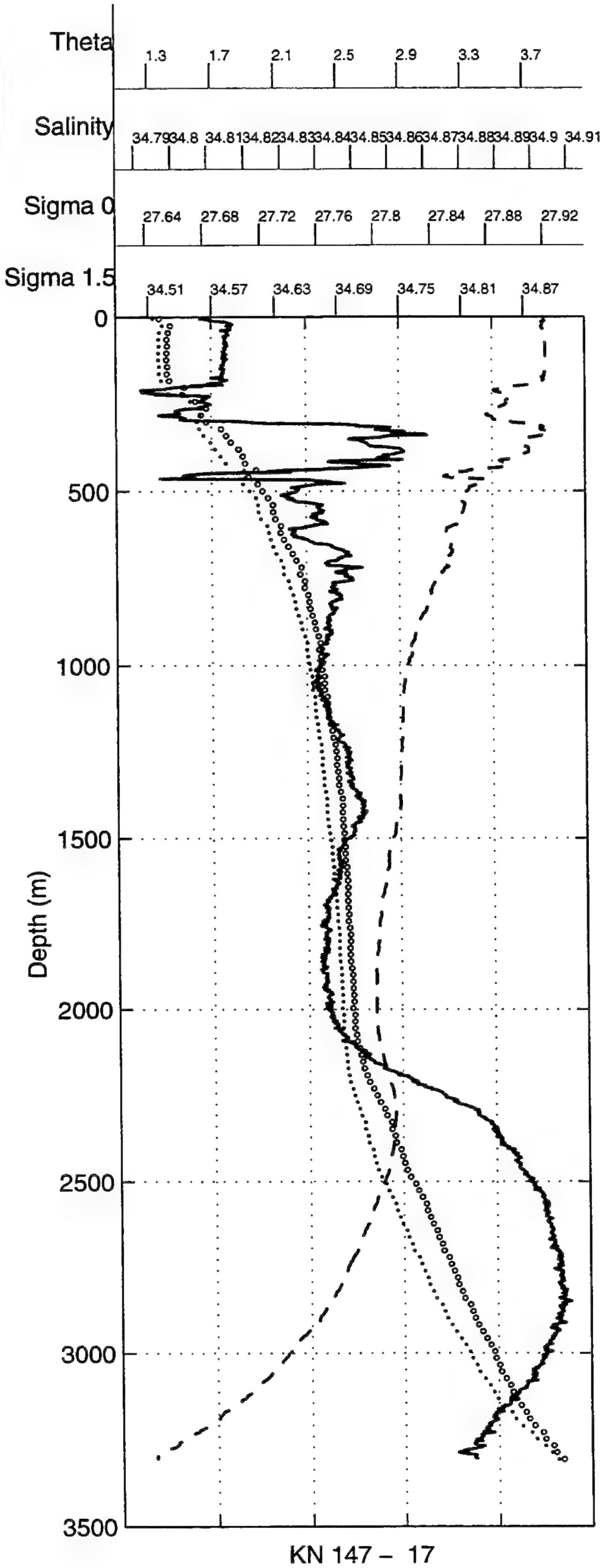

Theta
2.76 2.81 2.86 2.91 2.96 3.01 3.06 3.11
Salinity
34.77 34.78 34.79 34.8 34.81 34.82 34.83 34.84 34.85 34.86
Sigma 0
27.722 27.731 27.74 27.749 27.758 27.767 27.776
Sigma 1.5
34.62 34.63 34.64 34.65 34.66 34.67 34.68 34.69
Depth (m)
0 200 400 600 800 1000 1200 1400 1600 1800
KN 147 - 9
Theta
2.75 2.82 2.89 2.96 3.03 3.1 3.17
Salinity
34.78 34.79 34.8 34.81 34.82 34.83 34.84 34.85 34.86
Sigma 0
27.726 27.735 27.744 27.753 27.762 27.771 27.78
Sigma 1.5
34.62 34.63 34.64 34.65 34.66 34.67 34.68 34.69 34.7
Depth (m)
0 200 400 600 800 1000 1200 1400 1600 1800
KN 147 - 10
θ
S
σ0
σ1.5

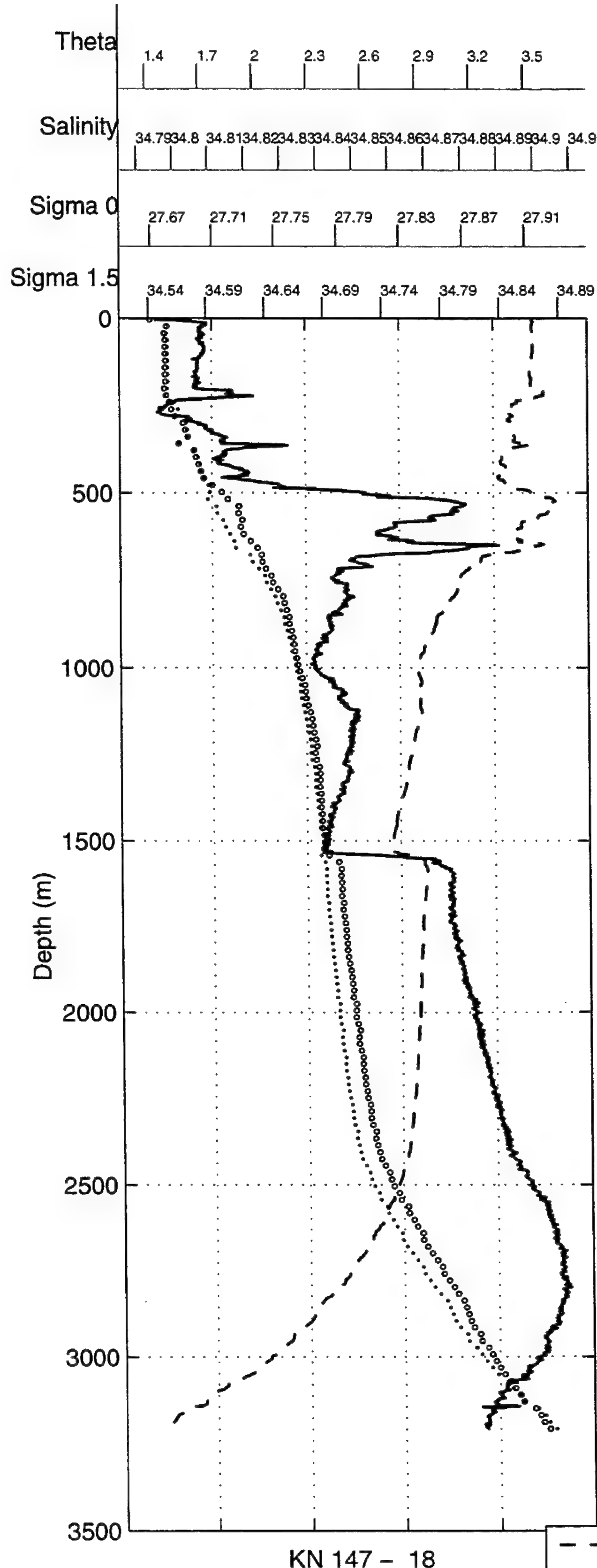

Theta
2.75 2.82 2.89 2.96 3.03 3.1 3.17
Salinity
34.8 34.809 34.818 34.827 34.836 34.845 34.854
Sigma 0
27.727 27.736 27.745 27.754 27.763 27.772 27.781
Sigma 1.5
34.62 34.63 34.64 34.65 34.66 34.67 34.68 34.69
Depth (m)
0 200 400 600 800 1000 1200 1400 1600 1800
KN 147 - 11
Theta
2.74 2.8 2.86 2.92 2.98 3.04 3.1
Salinity
34.77 34.78 34.79 34.8 34.81 34.82 34.83 34.84 34.85
Sigma 0
27.724 27.733 27.742 27.751 27.76 27.769 27.778
Sigma 1.5
34.62 34.63 34.64 34.65 34.66 34.67 34.68 34.69 34.7
Depth (m)
0 200 400 600 800 1000 1200 1400 1600 1800
KN 147 - 12
θ
S
σ0

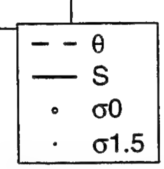

Theta
2.74 2.81 2.88 2.95 3.02 3.09 3.16
Salinity
34.78 34.79 34.8 34.81 34.82 34.83 34.84 34.85 34.86
Sigma 0
27.724 27.733 27.742 27.751 27.76 27.769 27.778
Sigma 1.5
34.62 34.63 34.64 34.65 34.66 34.67 34.68 34.69 34.7
Depth (m)
0
200
400
600
800
1000
1200
1400
1600
1800
KN 147 – 13
Theta
Salinity
Sigma 0
Sigma 1.5
Depth (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
No Data
KN 147 – 14
θ
S
σ0
σ1.5

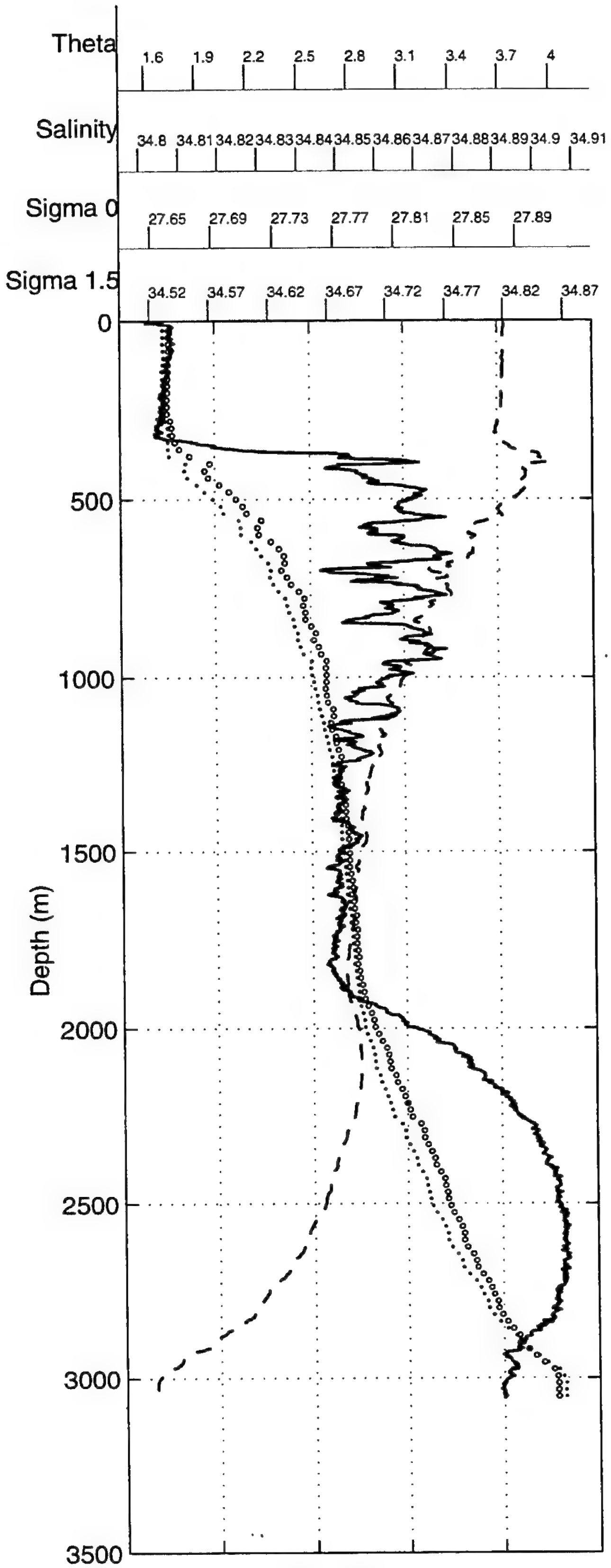


Theta
1.3 1.6 1.9 2.2 2.5 2.8 3.1
Salinity
34.75 34.77 34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.72 27.75 27.78 27.81 27.84 27.87 27.9 27.93
Sigma 1.5
34.62 34.66 34.7 34.74 34.78 34.82 34.86 34.9
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 - 15
Theta
1.2 1.5 1.8 2.1 2.4 2.7 3 3.3 3.6
Salinity
34.77 34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.66 27.7 27.74 27.78 27.82 27.86 27.9
Sigma 1.5
34.53 34.58 34.63 34.68 34.73 34.78 34.83 34.88
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 - 16
θ
S
σ0
σ1.5

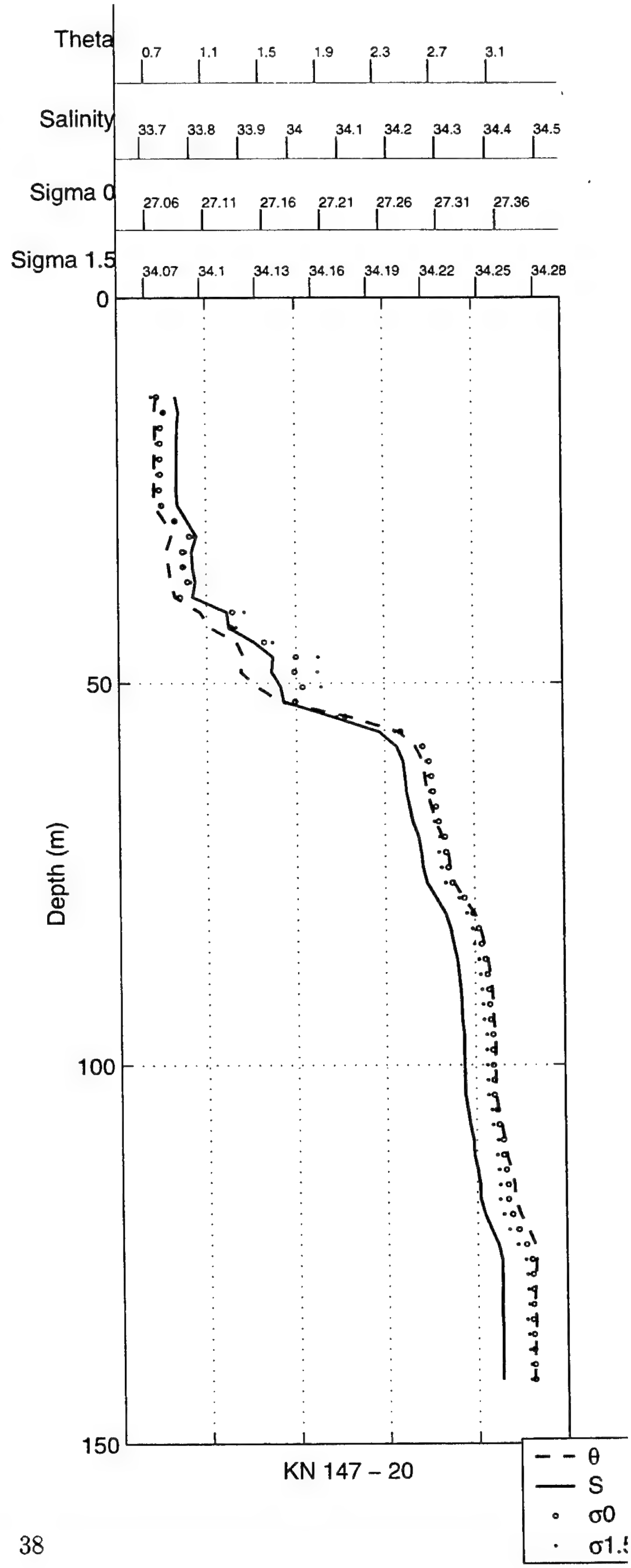

Theta
1.3 1.7 2.1 2.5 2.9 3.3 3.7
Salinity
34.79 34.8 34.81 34.82 34.83 34.84 34.85 34.86 34.87 34.88 34.89 34.9 34.91
Sigma 0
27.64 27.68 27.72 27.76 27.8 27.84 27.88 27.92
Sigma 1.5
34.51 34.57 34.63 34.69 34.75 34.81 34.87
0
500
1000
1500
2000
2500
3000
3500
Depth (m)
KN 147 – 17


Theta
1.4 1.7 2 2.3 2.6 2.9 3.2 3.5
Salinity
34.79 34.8 34.81 34.82 34.83 34.84 34.85 34.86 34.87 34.88 34.89 34.9 34.91
Sigma 0
27.67 27.71 27.75 27.79 27.83 27.87 27.91
Sigma 1.5
34.54 34.59 34.64 34.69 34.74 34.79 34.84 34.89
0
500
1000
1500
2000
2500
3000
3500
Depth (m)
KN 147 – 18

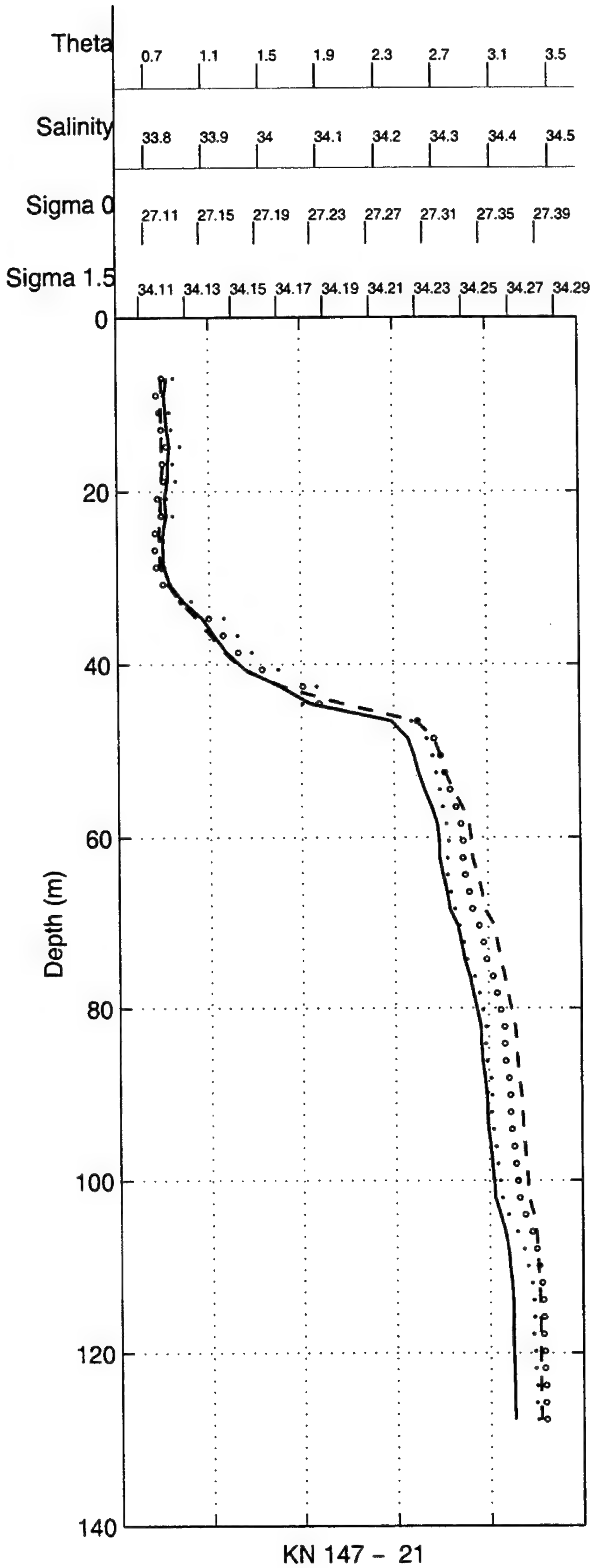

θ
S
σ0
σ1.5

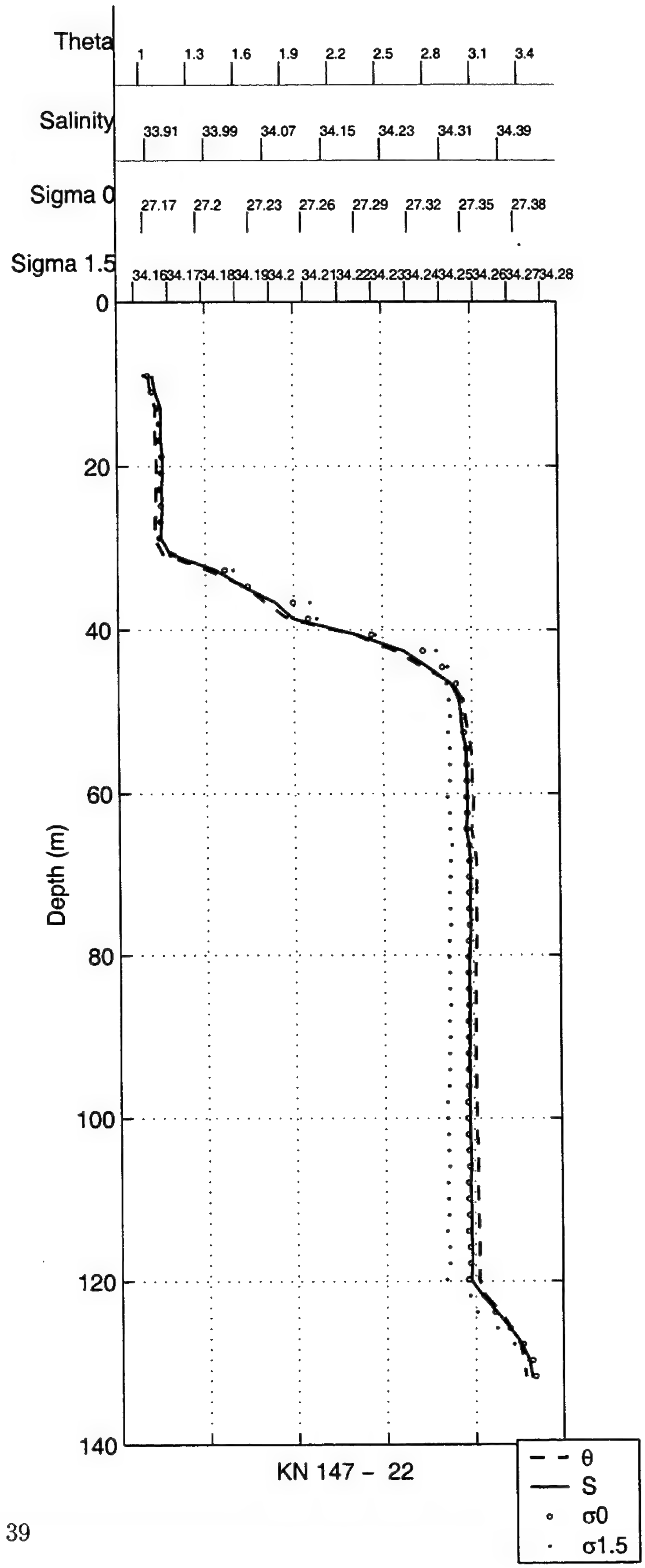


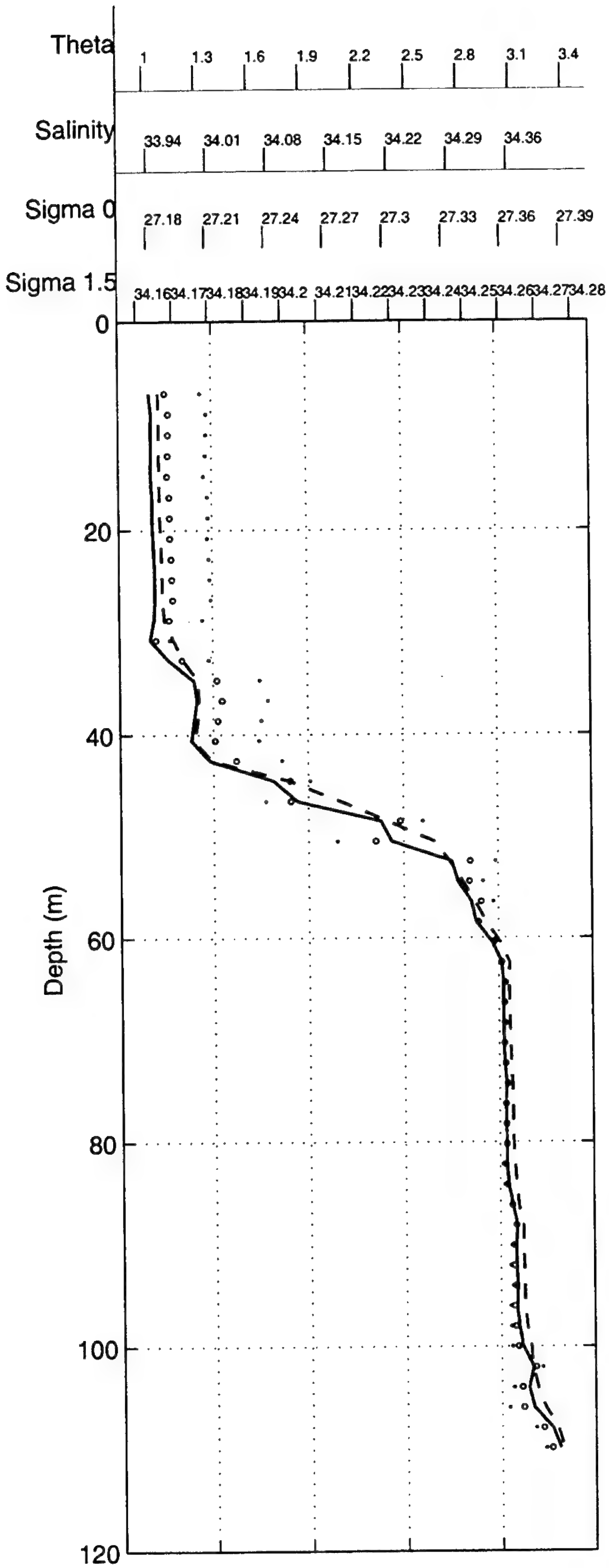
KN 147 – 19



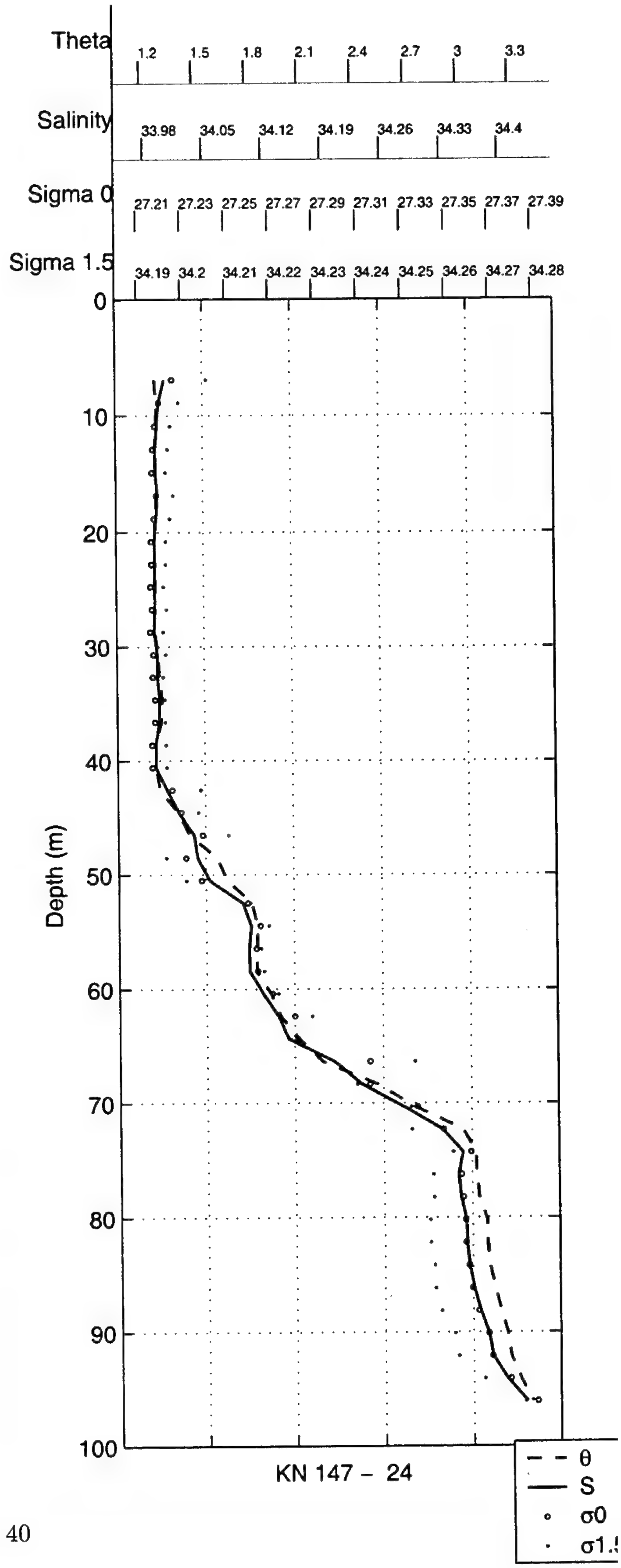
KN 147 – 20


Theta
0.7 1.1 1.5 1.9 2.3 2.7 3.1 3.5
Salinity
33.8 33.9 34 34.1 34.2 34.3 34.4 34.5
Sigma 0
27.11 27.15 27.19 27.23 27.27 27.31 27.35 27.39
Sigma 1.5
34.11 34.13 34.15 34.17 34.19 34.21 34.23 34.25 34.27 34.29
Depth (m)
0 20 40 60 80 100 120 140
KN 147 - 21

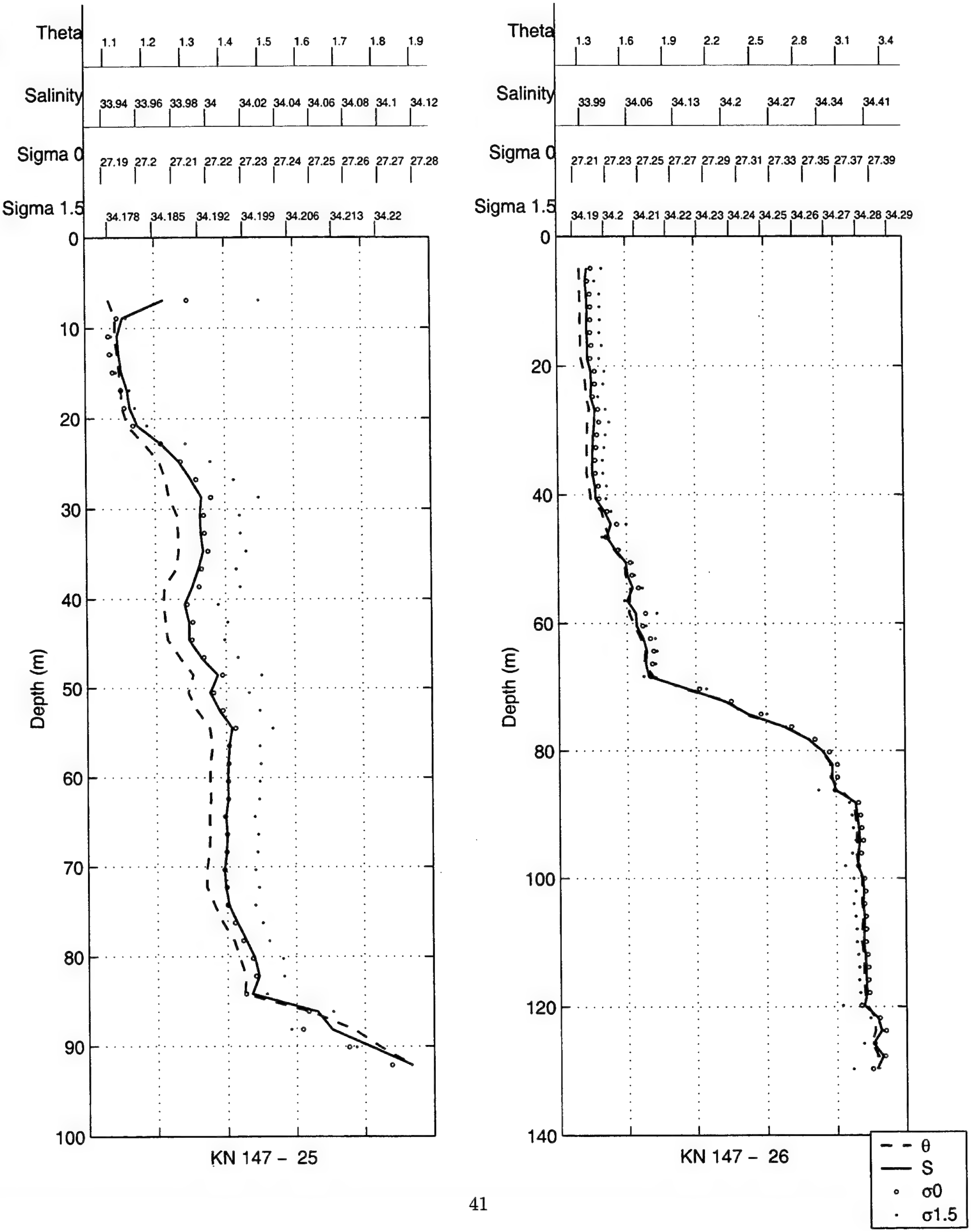

Theta
1 1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4
Salinity
33.91 33.99 34.07 34.15 34.23 34.31 34.39
Sigma 0
27.17 27.2 27.23 27.26 27.29 27.32 27.35 27.38
Sigma 1.5
34.16 34.17 34.18 34.19 34.2 34.21 34.22 34.23 34.24 34.25 34.26 34.27 34.28
Depth (m)
0 20 40 60 80 100 120 140
KN 147 - 22
θ
S
σ0
σ1.5

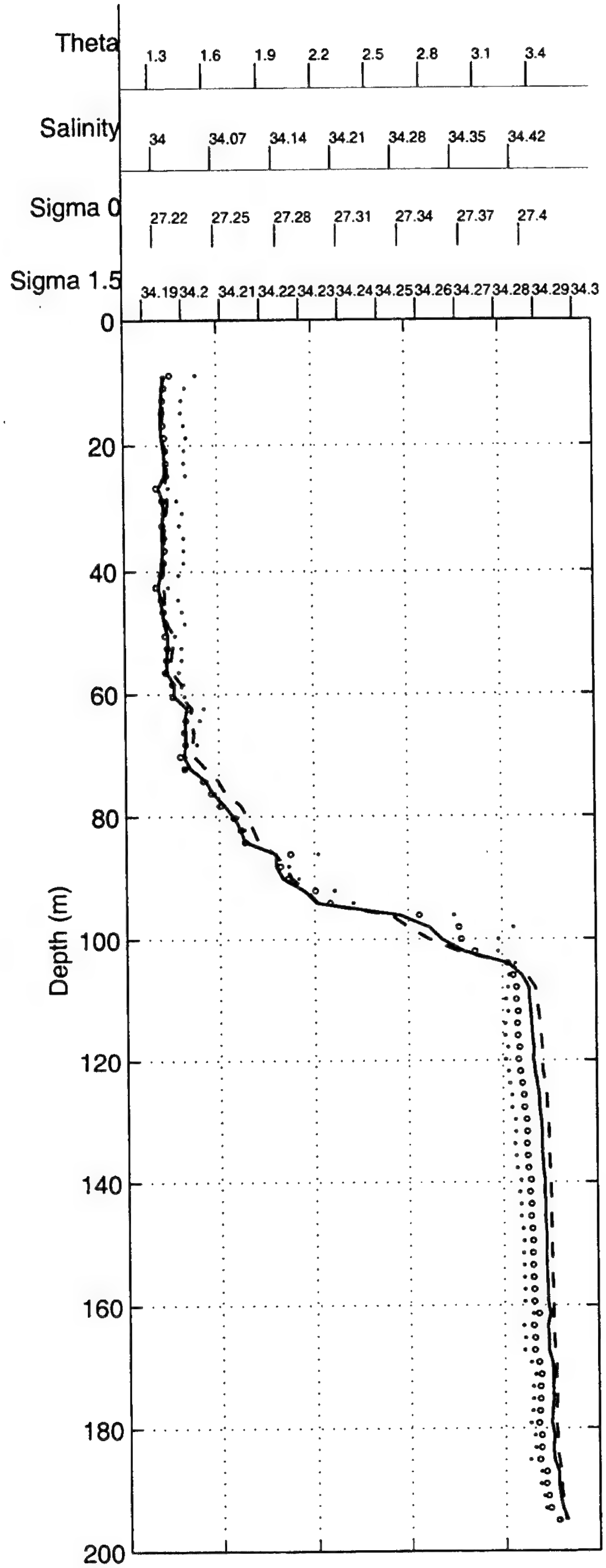


KN 147 - 23

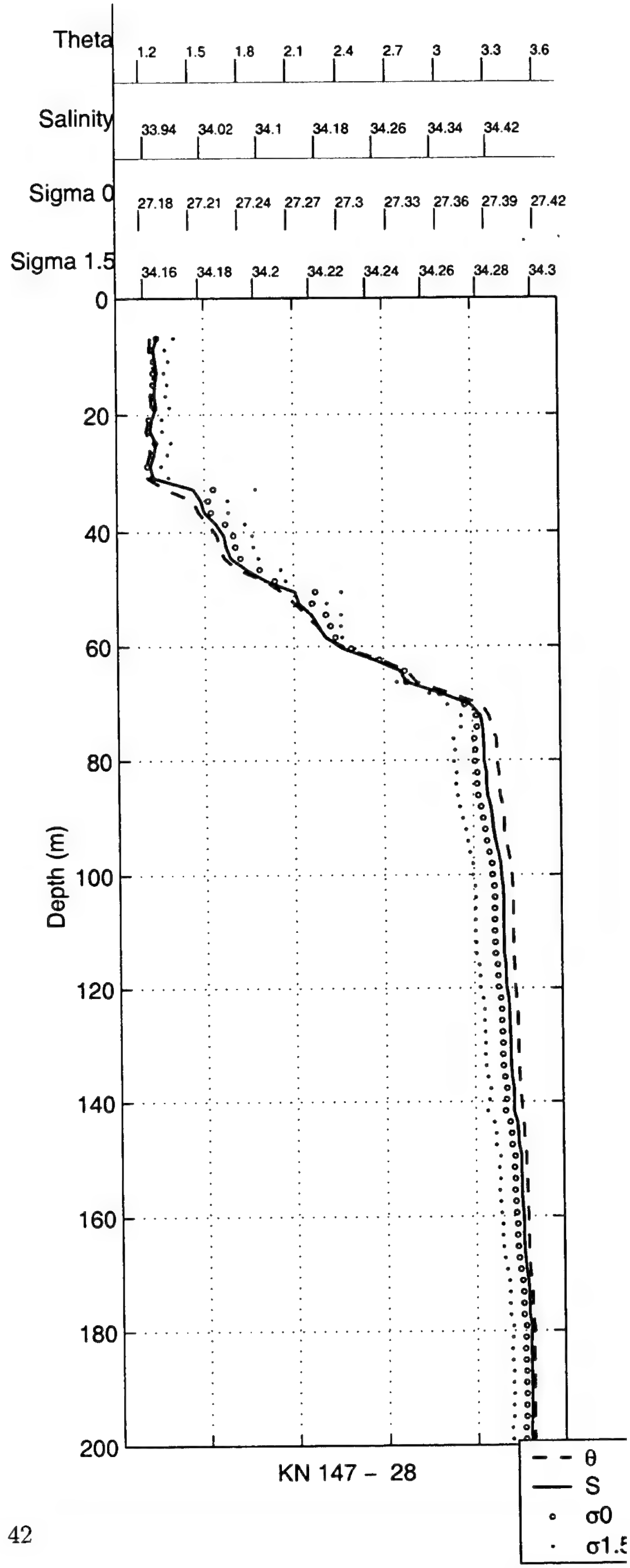


KN 147 - 24

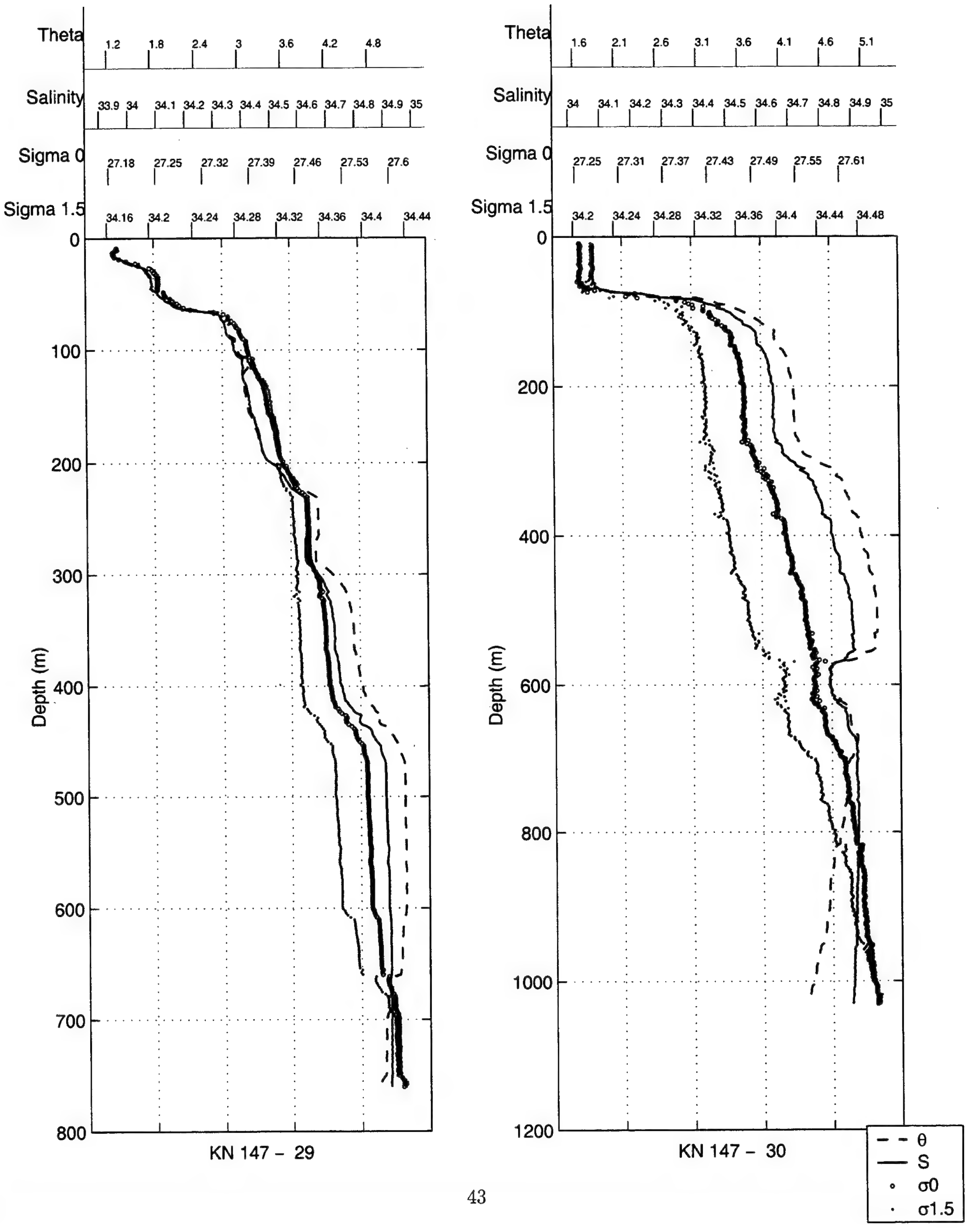

Theta
1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9
Salinity
33.94 33.96 33.98 34 34.02 34.04 34.06 34.08 34.1 34.12
Sigma 0
27.19 27.2 27.21 27.22 27.23 27.24 27.25 27.26 27.27 27.28
Sigma 1.5
34.178 34.185 34.192 34.199 34.206 34.213 34.22
Depth (m)
KN 147 - 25
Theta
1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4
Salinity
33.99 34.06 34.13 34.2 34.27 34.34 34.41
Sigma 0
27.21 27.23 27.25 27.27 27.29 27.31 27.33 27.35 27.37 27.39
Sigma 1.5
34.19 34.2 34.21 34.22 34.23 34.24 34.25 34.26 34.27 34.28 34.29
Depth (m)
KN 147 - 26
θ
S
σ0
σ1.5



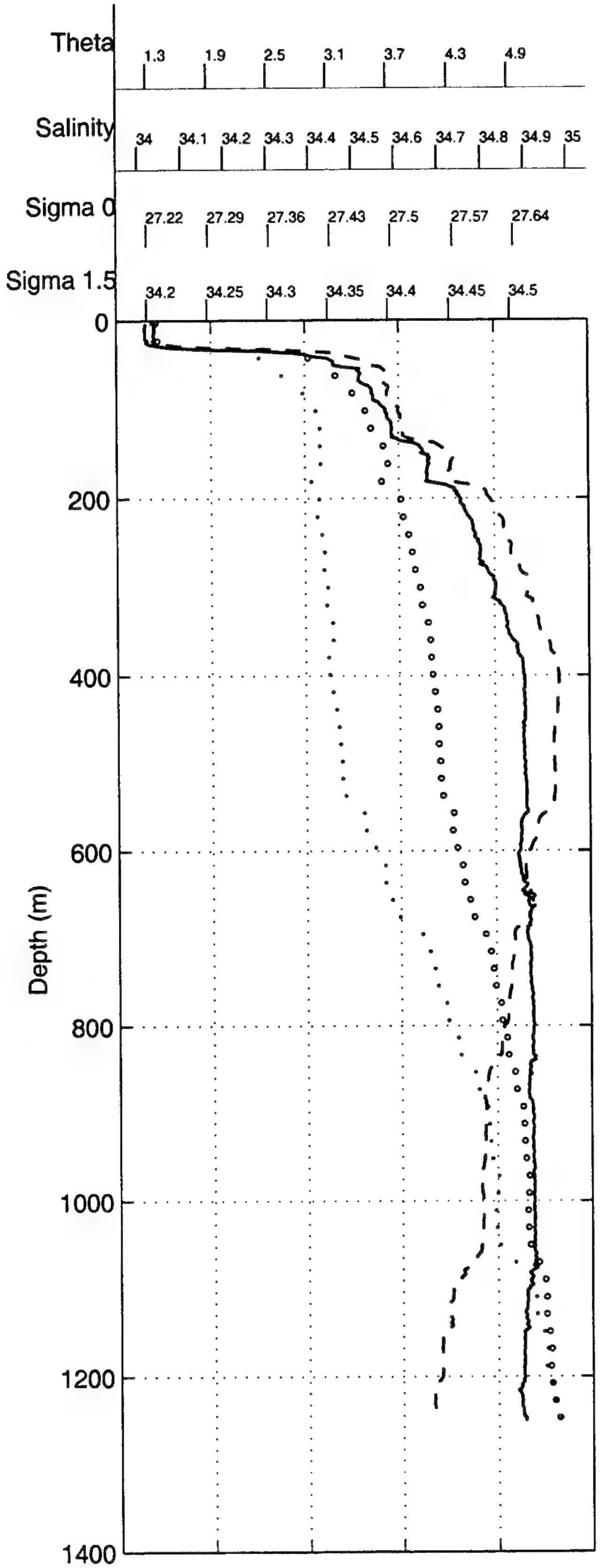
KN 147 - 27



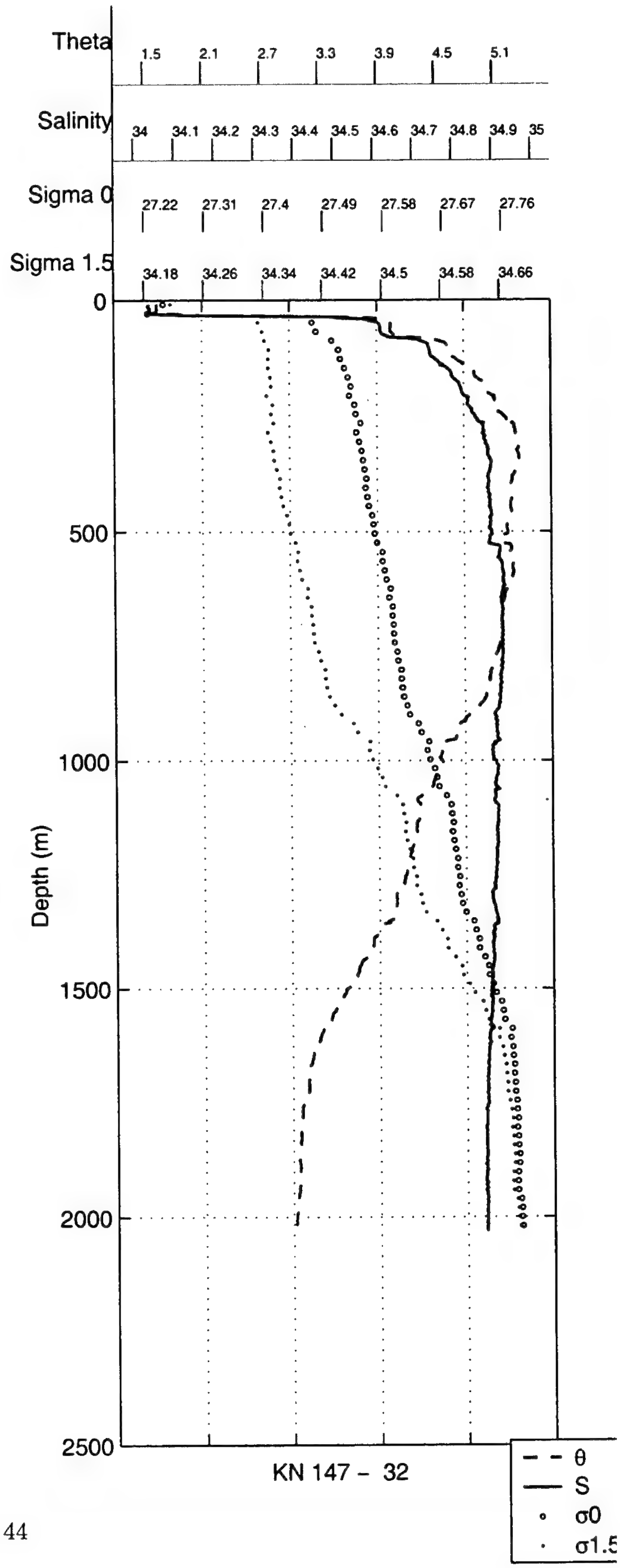
KN 147 - 28



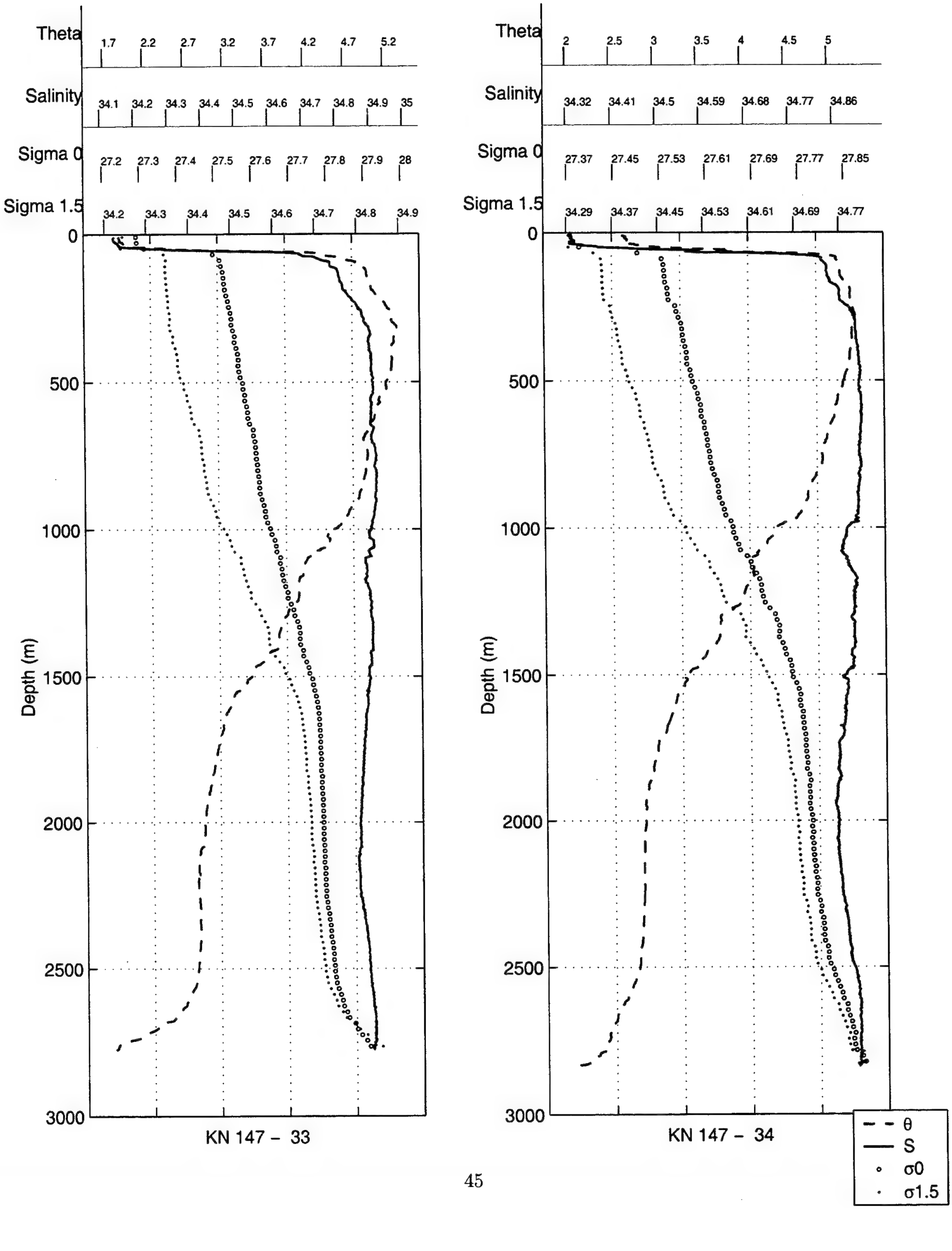
Theta
1.2 1.8 2.4 3 3.6 4.2 4.8
Salinity
33.9 34 34.1 34.2 34.3 34.4 34.5 34.6 34.7 34.8 34.9 35
Sigma 0
27.18 27.25 27.32 27.39 27.46 27.53 27.6
Sigma 1.5
34.16 34.2 34.24 34.28 34.32 34.36 34.4 34.44
Depth (m)
0 100 200 300 400 500 600 700 800
KN 147 - 29
Theta
1.6 2.1 2.6 3.1 3.6 4.1 4.6 5.1
Salinity
34 34.1 34.2 34.3 34.4 34.5 34.6 34.7 34.8 34.9 35
Sigma 0
27.25 27.31 27.37 27.43 27.49 27.55 27.61
Sigma 1.5
34.2 34.24 34.28 34.32 34.36 34.4 34.44 34.48
Depth (m)
0 200 400 600 800 1000 1200
KN 147 - 30
θ
S
σ0
σ1.5



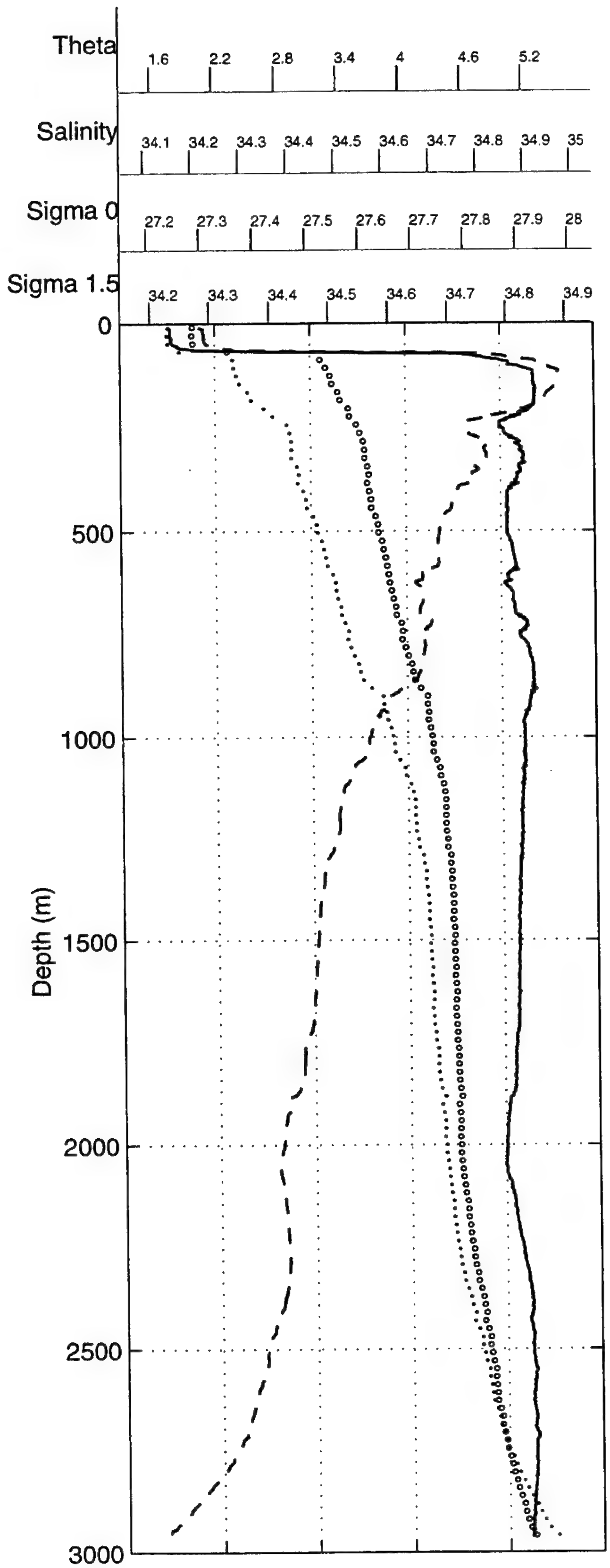
KN 147 - 31



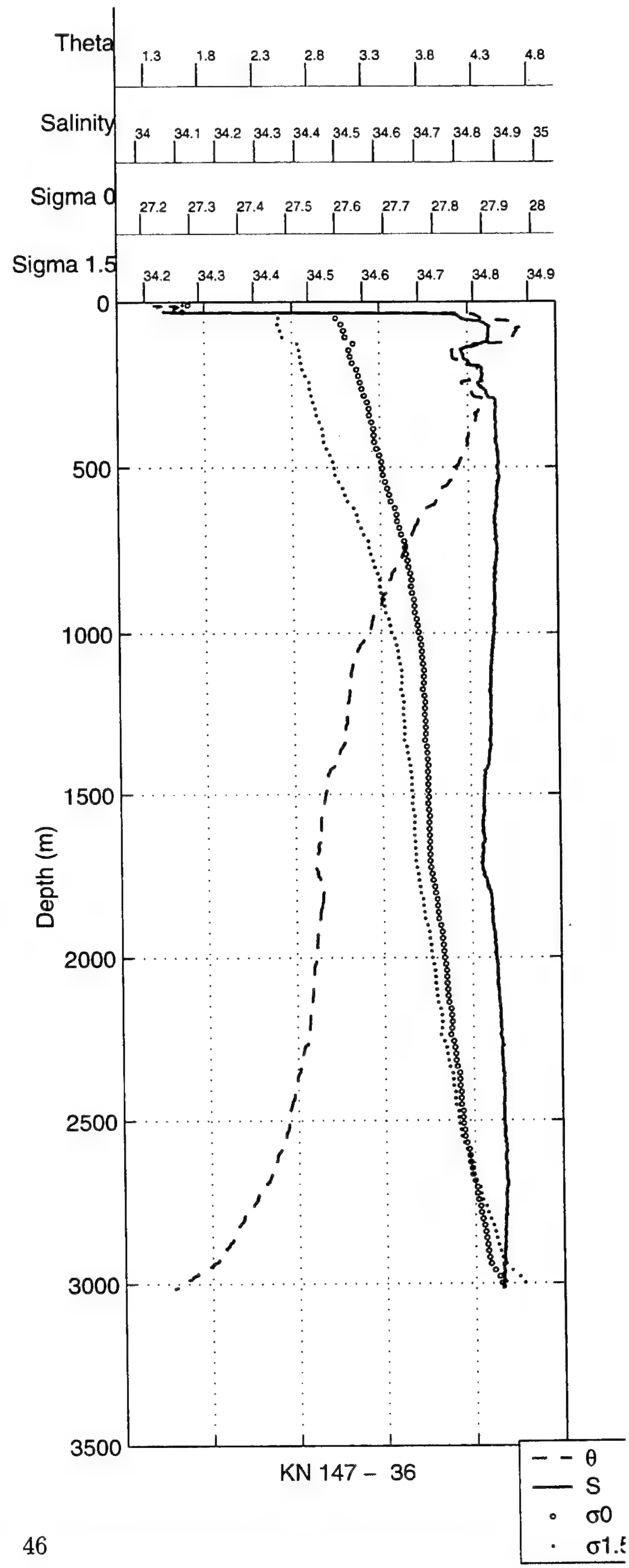
KN 147 - 32



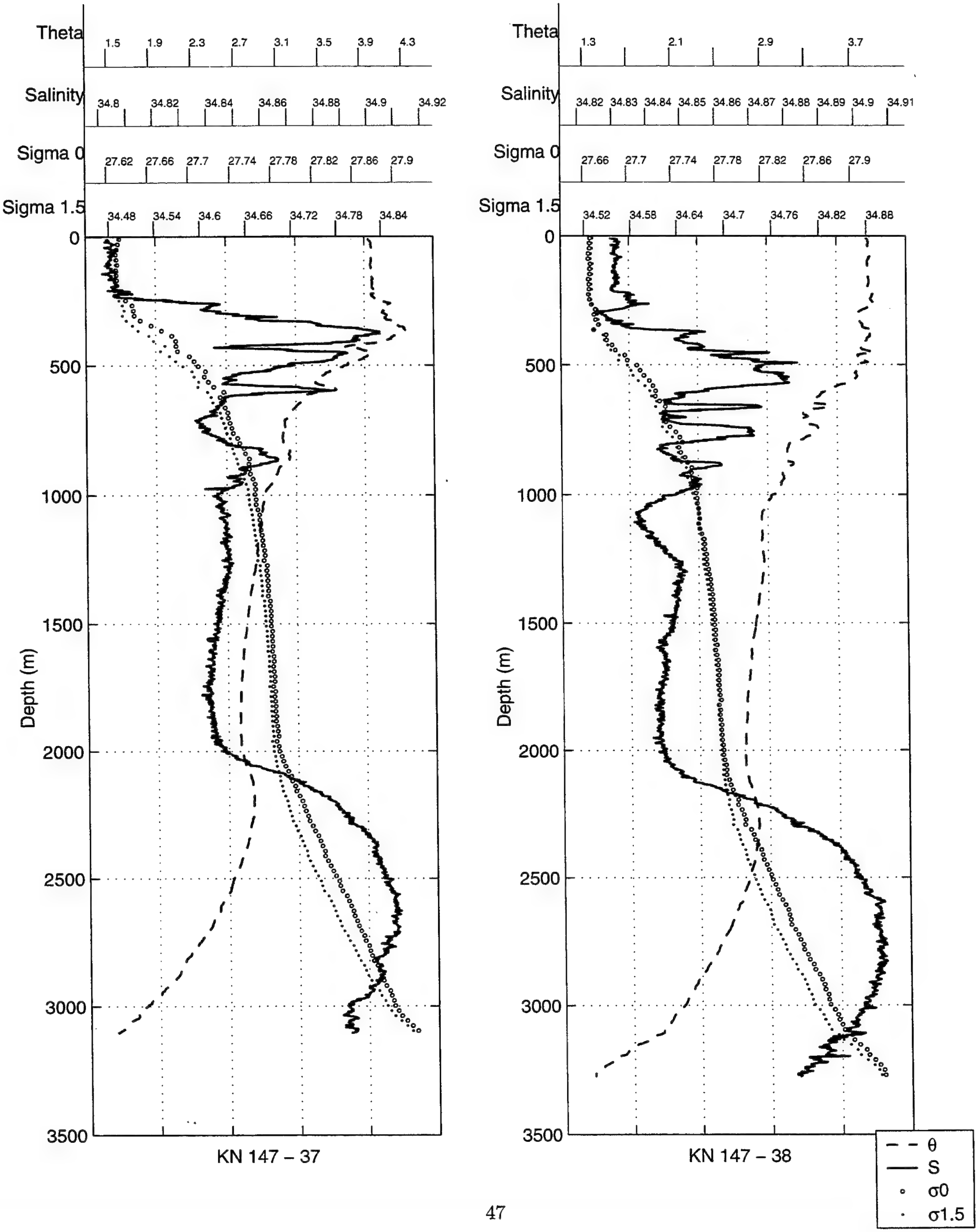
Theta
1.7 2.2 2.7 3.2 3.7 4.2 4.7 5.2
Salinity
34.1 34.2 34.3 34.4 34.5 34.6 34.7 34.8 34.9 35
Sigma 0
27.2 27.3 27.4 27.5 27.6 27.7 27.8 27.9 28
Sigma 1.5
34.2 34.3 34.4 34.5 34.6 34.7 34.8 34.9
Depth (m)
0 500 1000 1500 2000 2500 3000
KN 147 - 33
Theta
2 2.5 3 3.5 4 4.5 5
Salinity
34.32 34.41 34.5 34.59 34.68 34.77 34.86
Sigma 0
27.37 27.45 27.53 27.61 27.69 27.77 27.85
Sigma 1.5
34.29 34.37 34.45 34.53 34.61 34.69 34.77
Depth (m)
0 500 1000 1500 2000 2500 3000
KN 147 - 34
θ
S
σ0
σ1.5

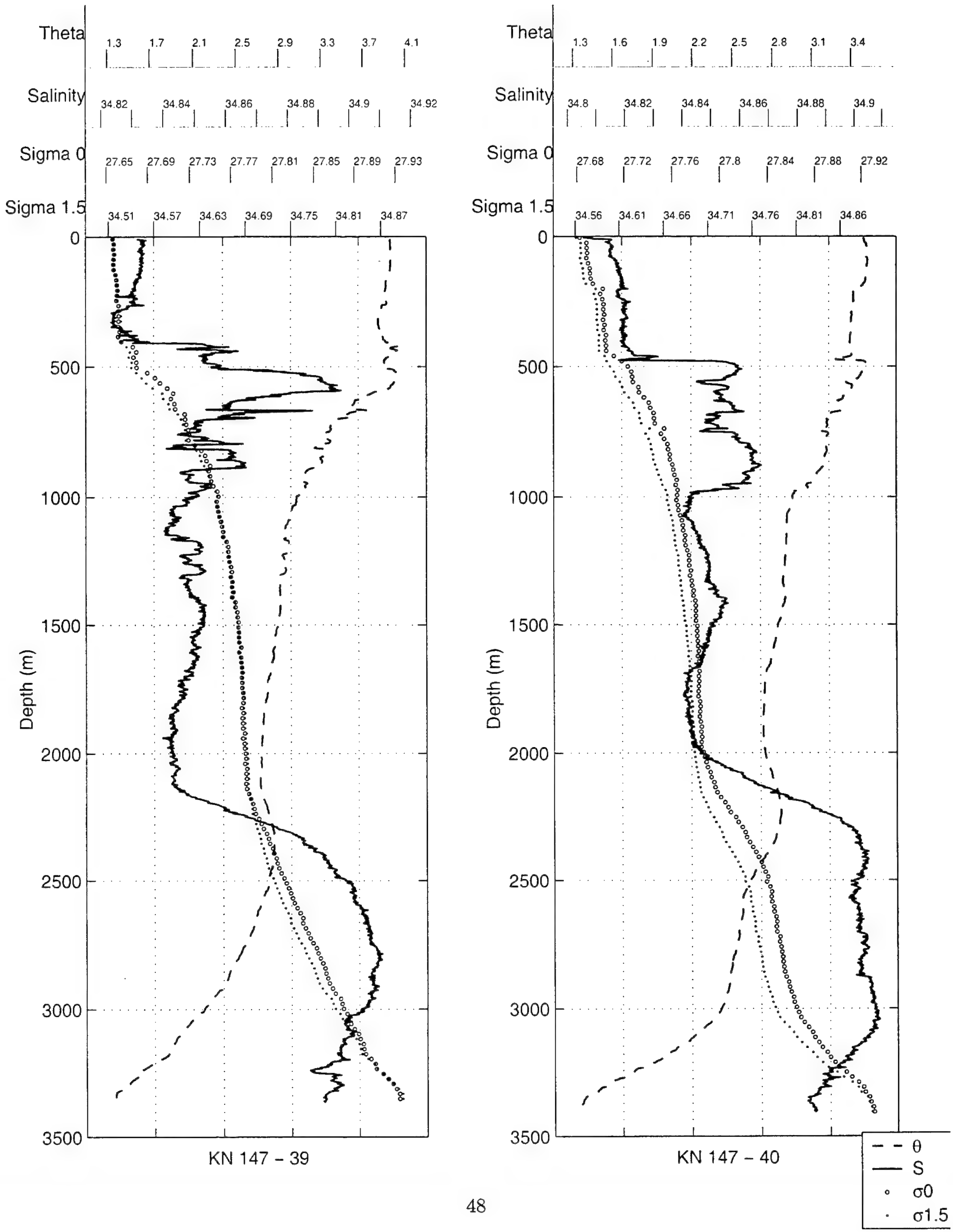


KN 147 - 35

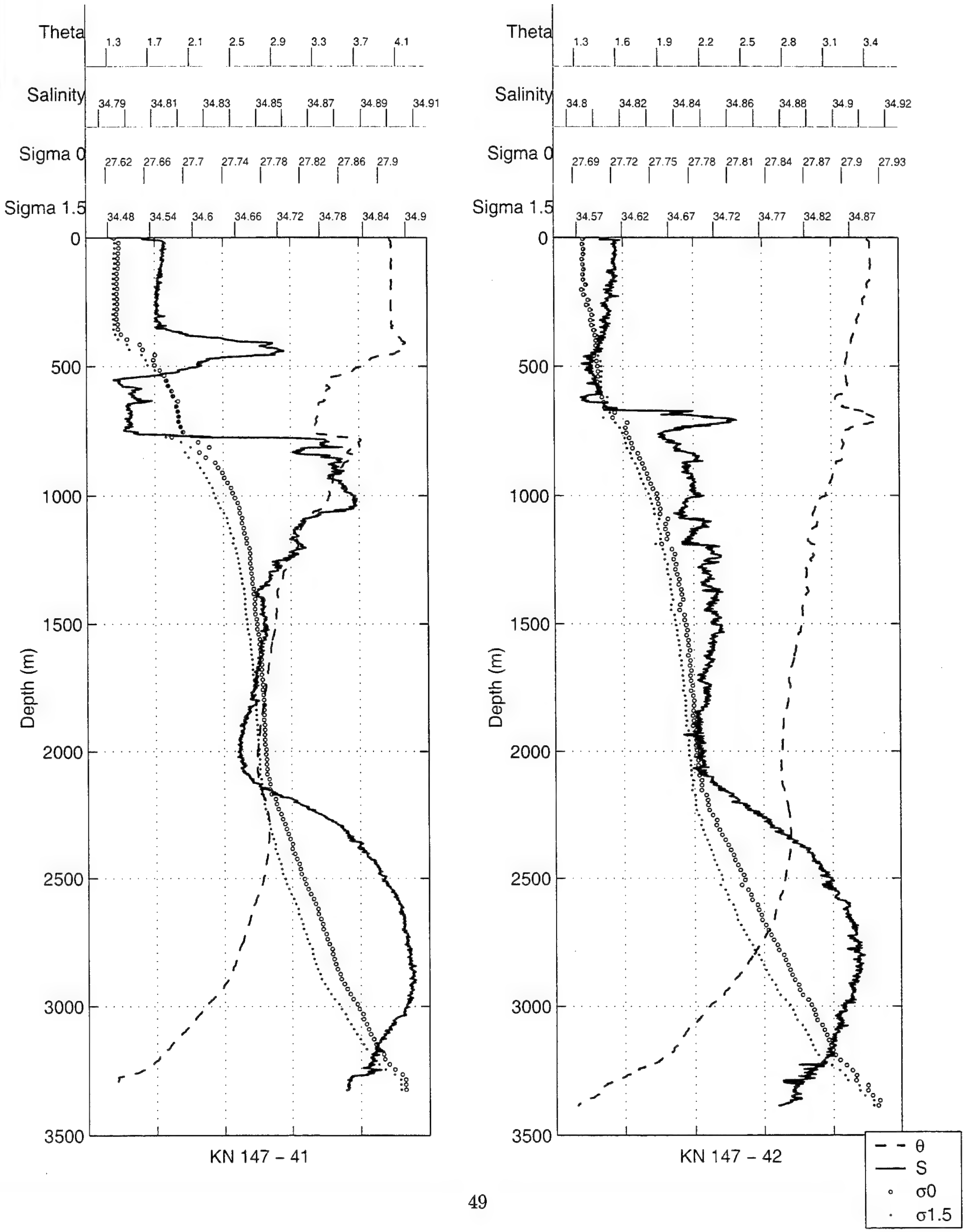


KN 147 - 36

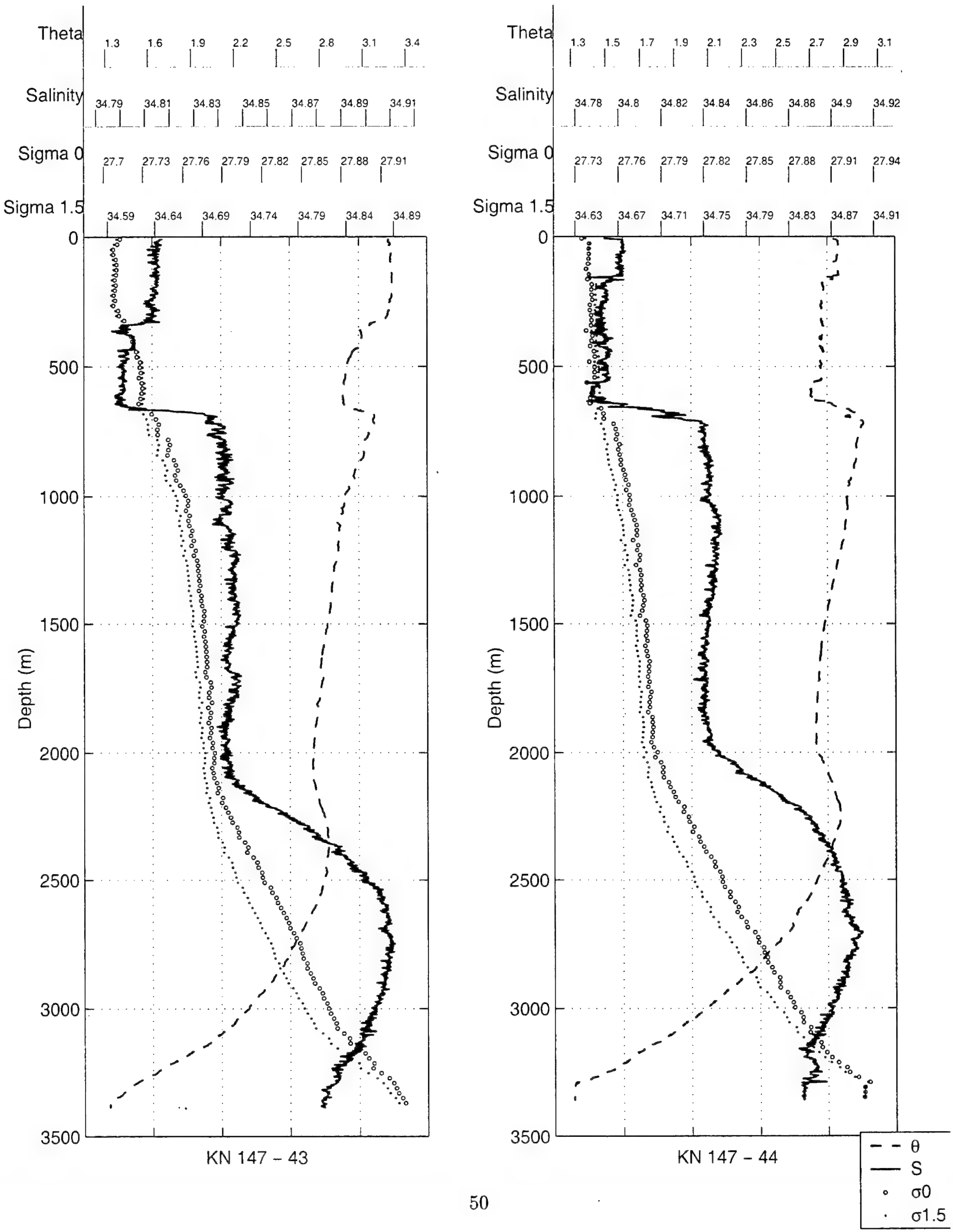

Theta
1.5 1.9 2.3 2.7 3.1 3.5 3.9 4.3
Salinity
34.8 34.82 34.84 34.86 34.88 34.9 34.92
Sigma 0
27.62 27.66 27.7 27.74 27.78 27.82 27.86 27.9
Sigma 1.5
34.48 34.54 34.6 34.66 34.72 34.78 34.84
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 37
Theta
1.3 2.1 2.9 3.7
Salinity
34.82 34.83 34.84 34.85 34.86 34.87 34.88 34.89 34.9 34.91
Sigma 0
27.66 27.7 27.74 27.78 27.82 27.86 27.9
Sigma 1.5
34.52 34.58 34.64 34.7 34.76 34.82 34.88
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 38
θ
S
σ0
σ1.5

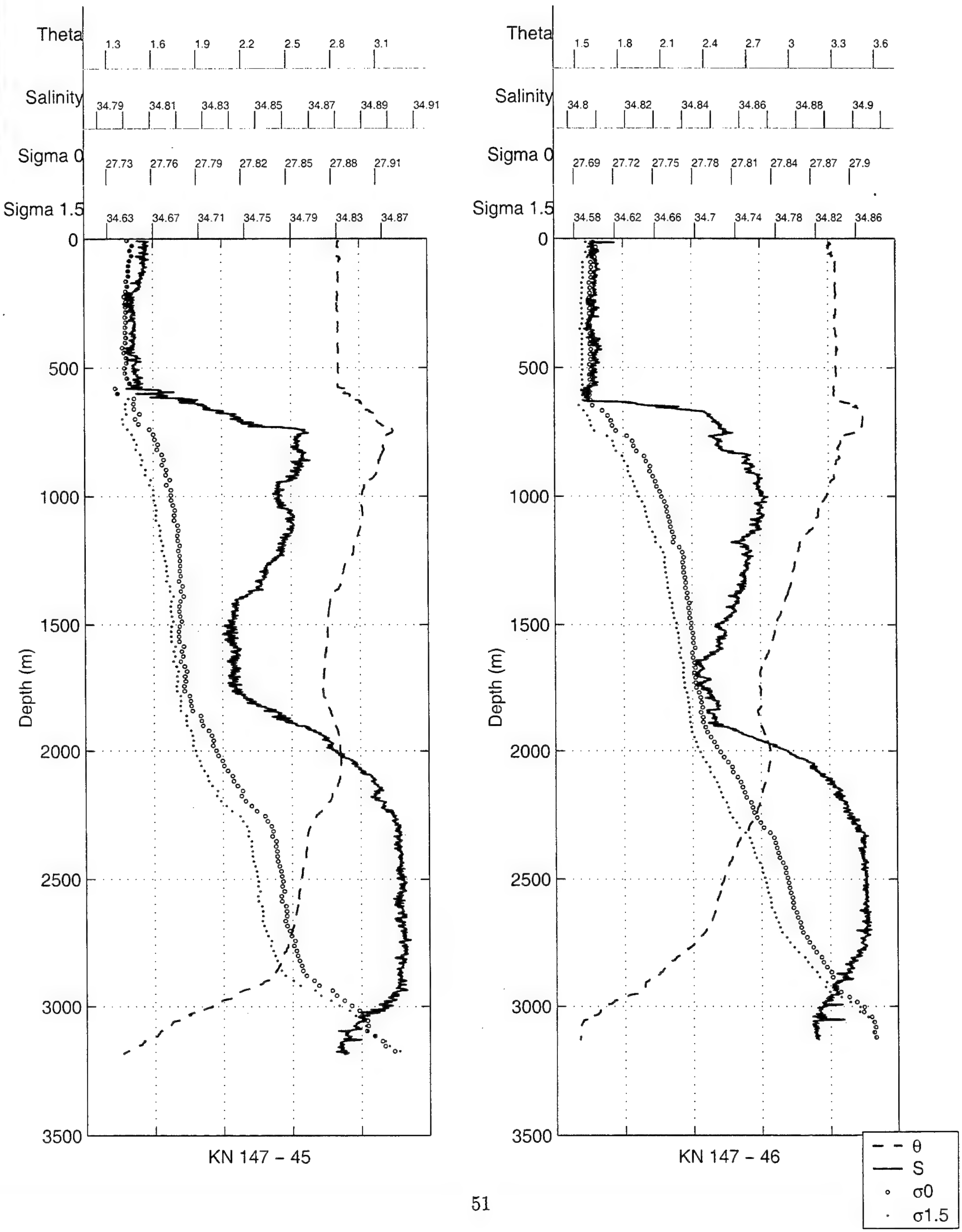


Theta
1.3 1.7 2.1 2.5 2.9 3.3 3.7 4.1
Salinity
34.82 34.84 34.86 34.88 34.9 34.92
Sigma 0
27.65 27.69 27.73 27.77 27.81 27.85 27.89 27.93
Sigma 1.5
34.51 34.57 34.63 34.69 34.75 34.81 34.87
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 - 39
Theta
1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4
Salinity
34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.68 27.72 27.76 27.8 27.84 27.88 27.92
Sigma 1.5
34.56 34.61 34.66 34.71 34.76 34.81 34.86
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 - 40
θ
S
σ0
σ1.5

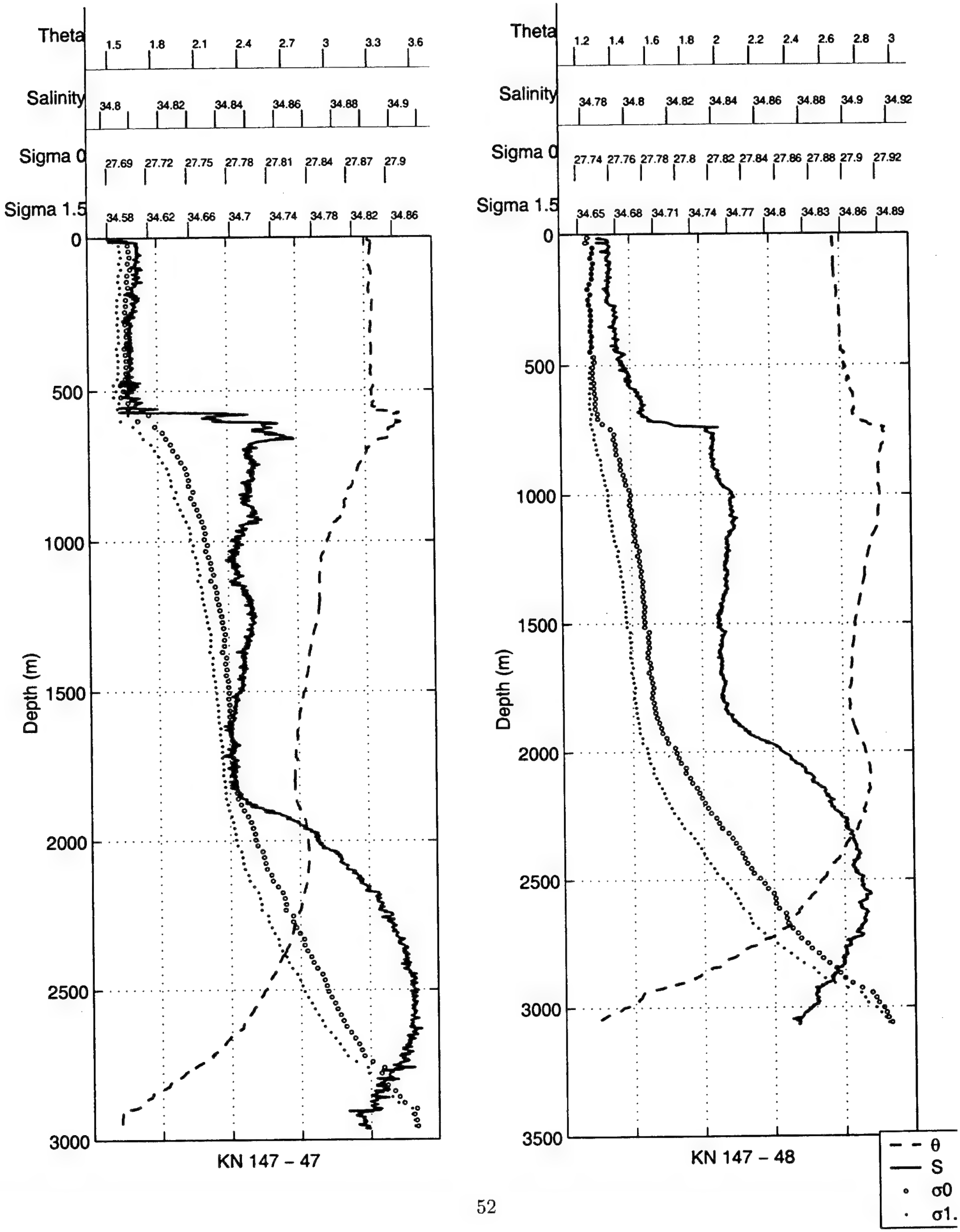


Theta
1.3
1.7
2.1
2.5
2.9
3.3
3.7
4.1
Salinity
34.79
34.81
34.83
34.85
34.87
34.89
34.91
Sigma 0
27.62
27.66
27.7
27.74
27.78
27.82
27.86
27.9
Sigma 1.5
34.48
34.54
34.6
34.66
34.72
34.78
34.84
34.9
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
KN 147 – 41
Theta
1.3
1.6
1.9
2.2
2.5
2.8
3.1
3.4
Salinity
34.8
34.82
34.84
34.86
34.88
34.9
34.92
Sigma 0
27.69
27.72
27.75
27.78
27.81
27.84
27.87
27.9
27.93
Sigma 1.5
34.57
34.62
34.67
34.72
34.77
34.82
34.87
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
KN 147 – 42
θ
S
σ0
σ1.5

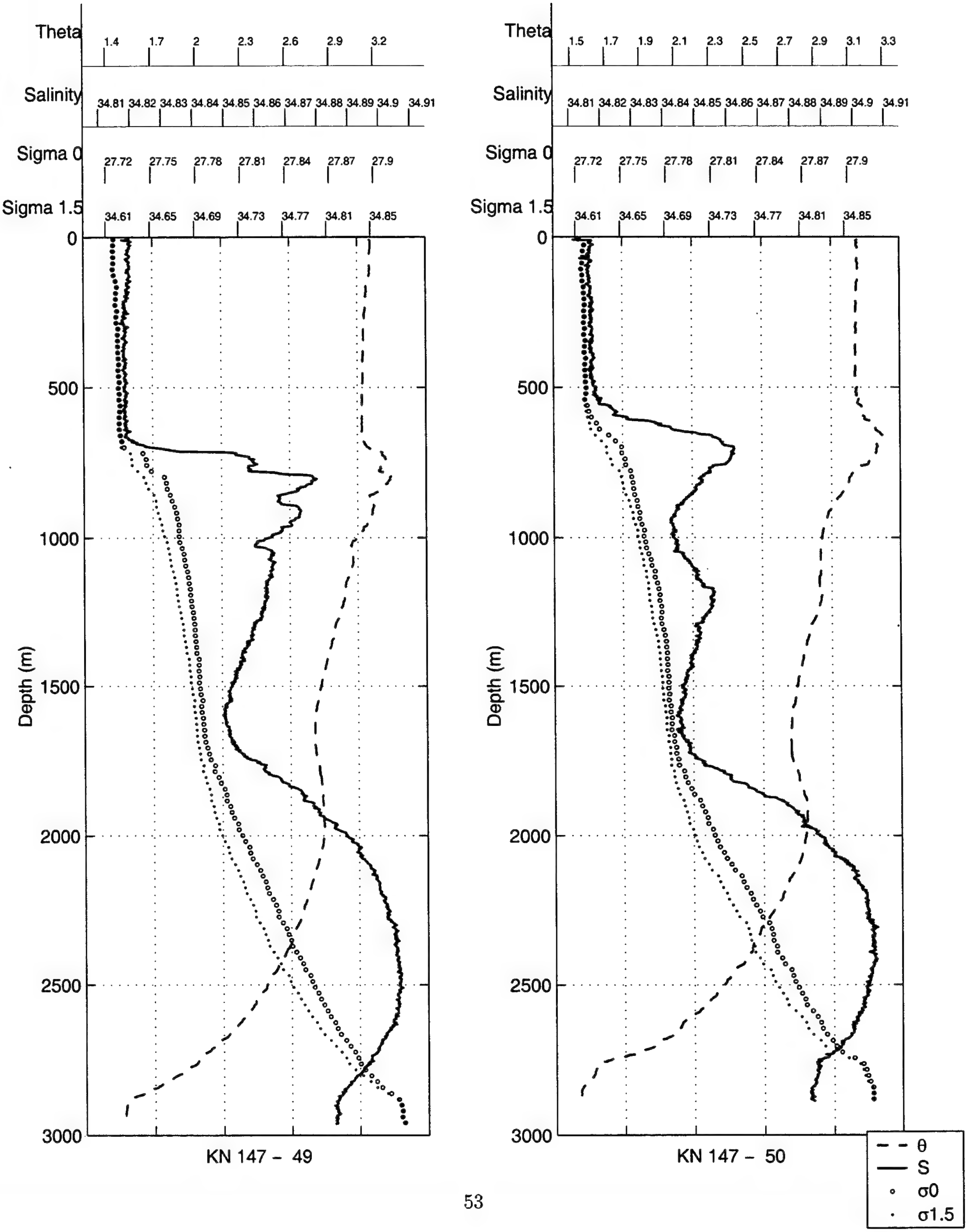

Theta
1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4
Salinity
34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.7 27.73 27.76 27.79 27.82 27.85 27.88 27.91
Sigma 1.5
34.59 34.64 34.69 34.74 34.79 34.84 34.89
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 43
Theta
1.3 1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9 3.1
Salinity
34.78 34.8 34.82 34.84 34.86 34.88 34.9 34.92
Sigma 0
27.73 27.76 27.79 27.82 27.85 27.88 27.91 27.94
Sigma 1.5
34.63 34.67 34.71 34.75 34.79 34.83 34.87 34.91
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 44
θ
S
σ0
σ1.5



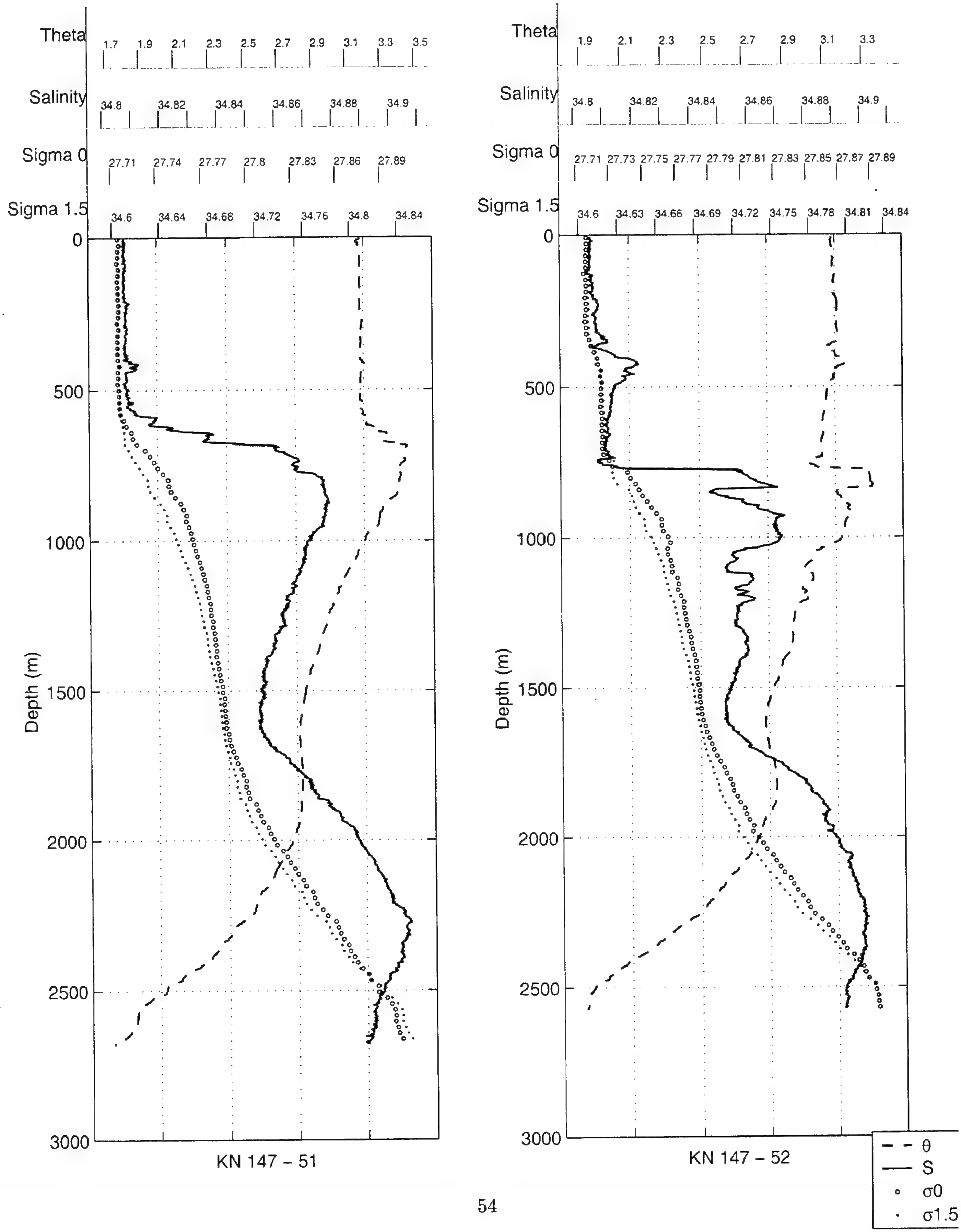
Theta
1.3 1.6 1.9 2.2 2.5 2.8 3.1
Salinity
34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.73 27.76 27.79 27.82 27.85 27.88 27.91
Sigma 1.5
34.63 34.67 34.71 34.75 34.79 34.83 34.87
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 - 45
Theta
1.5 1.8 2.1 2.4 2.7 3 3.3 3.6
Salinity
34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.69 27.72 27.75 27.78 27.81 27.84 27.87 27.9
Sigma 1.5
34.58 34.62 34.66 34.7 34.74 34.78 34.82 34.86
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 - 46
θ
S
σ0
σ1.5



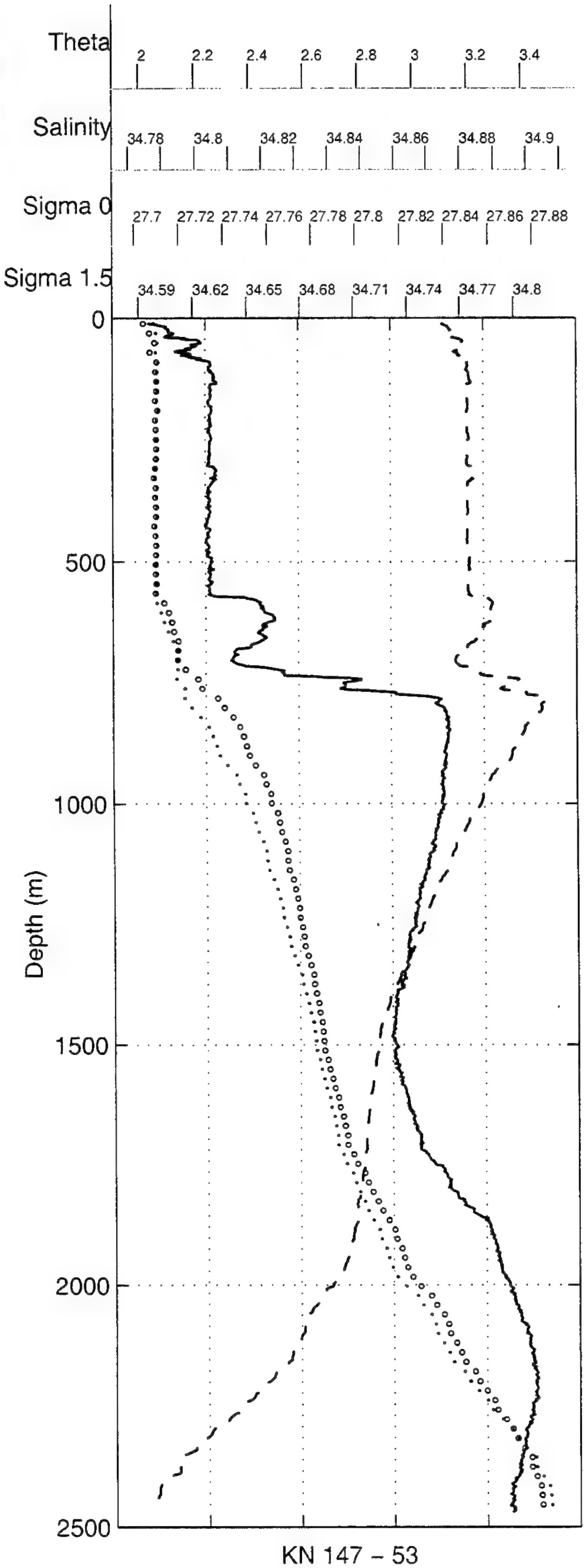
Theta
1.5 1.8 2.1 2.4 2.7 3 3.3 3.6
Salinity
34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.69 27.72 27.75 27.78 27.81 27.84 27.87 27.9
Sigma 1.5
34.58 34.62 34.66 34.7 34.74 34.78 34.82 34.86
Depth (m)
0 500 1000 1500 2000 2500 3000
KN 147 – 47
Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.78 34.8 34.82 34.84 34.86 34.88 34.9 34.92
Sigma 0
27.74 27.76 27.78 27.8 27.82 27.84 27.86 27.88 27.9 27.92
Sigma 1.5
34.65 34.68 34.71 34.74 34.77 34.8 34.83 34.86 34.89
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 48
θ
S
σ0
σ1.

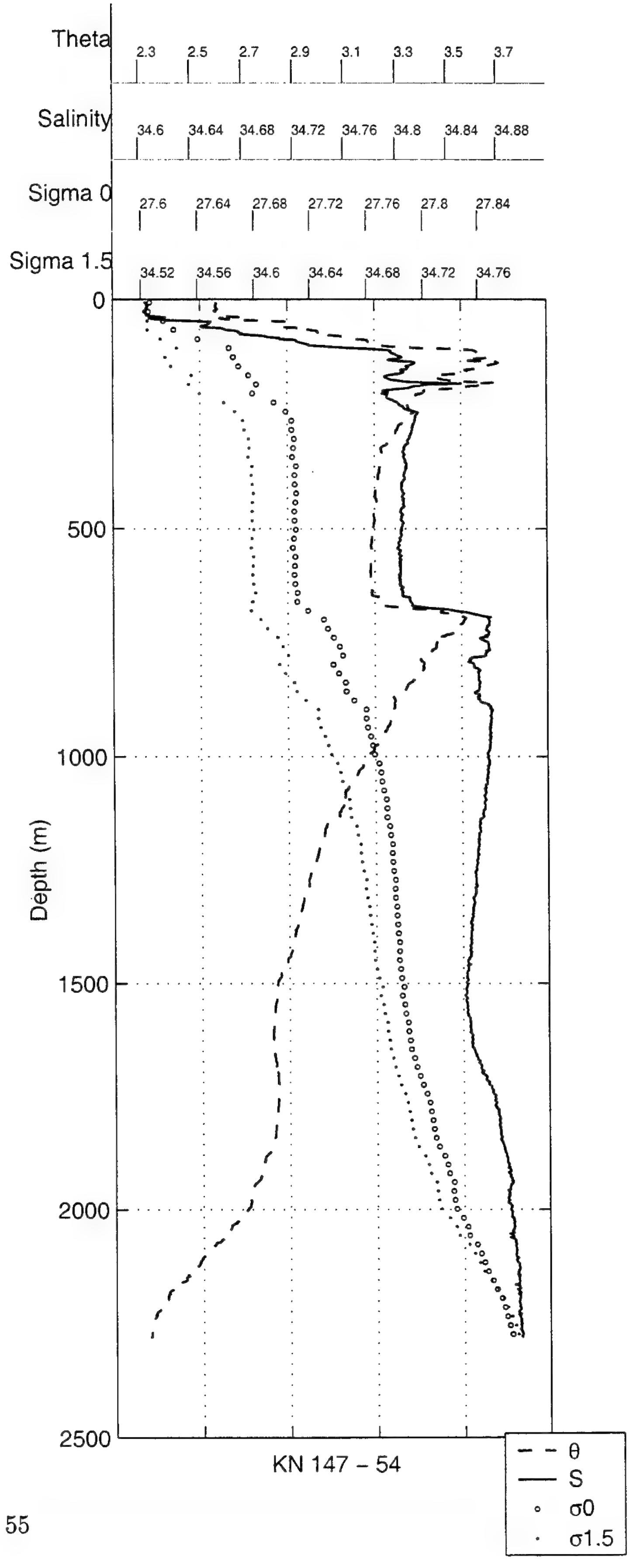


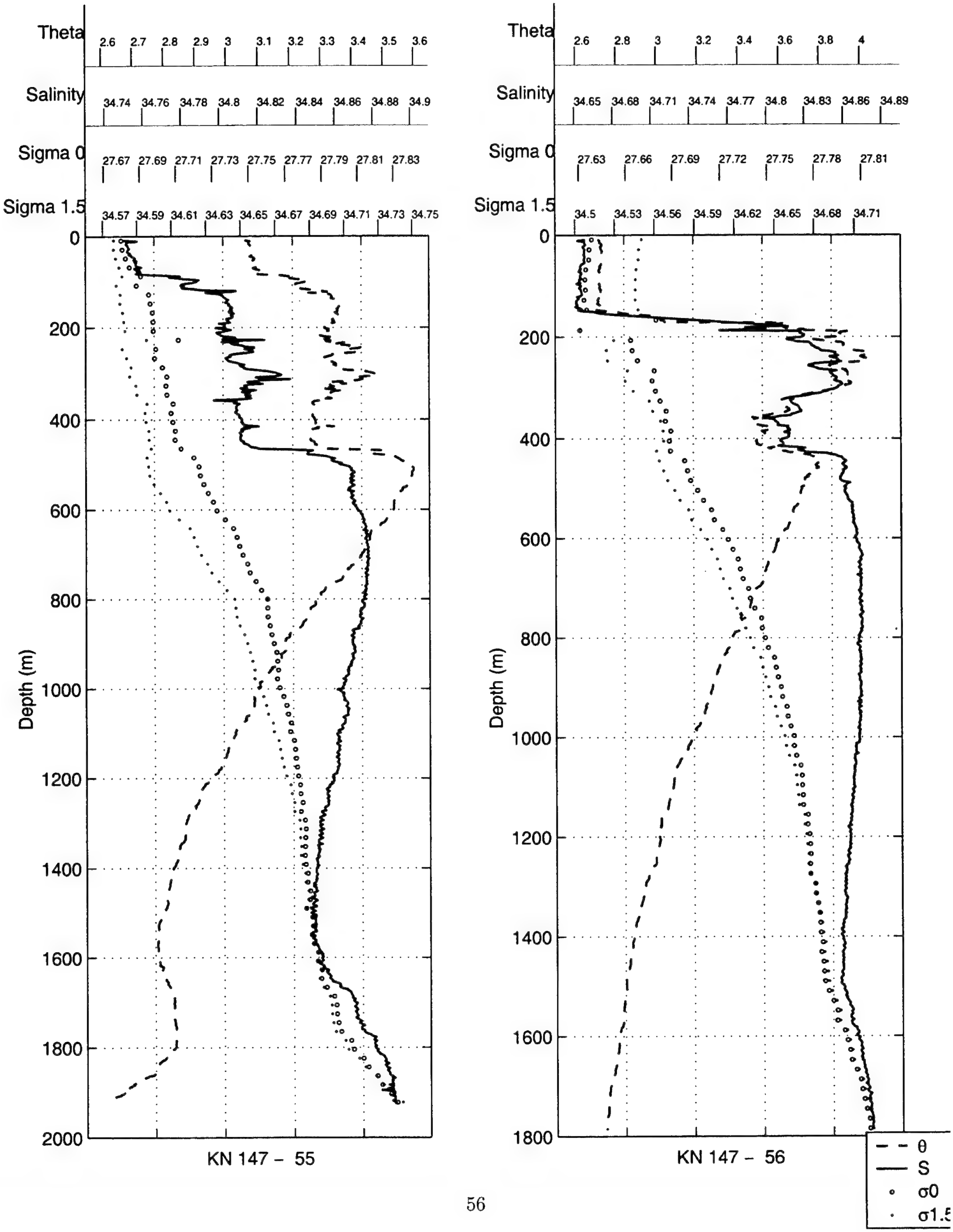
Theta
1.4
1.7
2
2.3
2.6
2.9
3.2
Salinity
34.81 34.82 34.83 34.84 34.85 34.86 34.87 34.88 34.89 34.9 34.91
Sigma 0
27.72
27.75
27.78
27.81
27.84
27.87
27.9
Sigma 1.5
34.61
34.65
34.69
34.73
34.77
34.81
34.85
0
500
1000
1500
2000
2500
3000
Depth (m)
KN 147 - 49
Theta
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
KN 147 - 50
θ
S
σ0
σ1.5

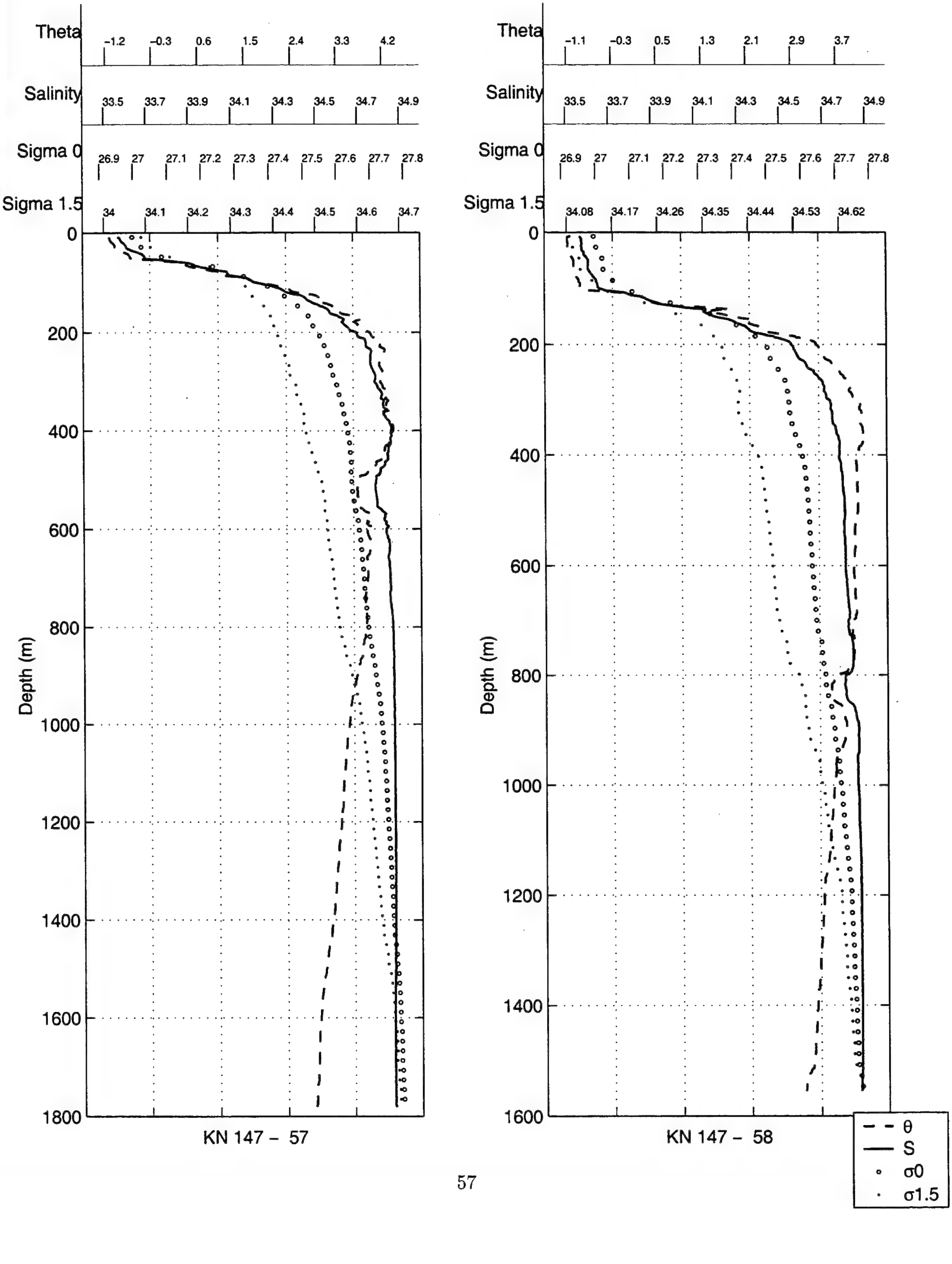


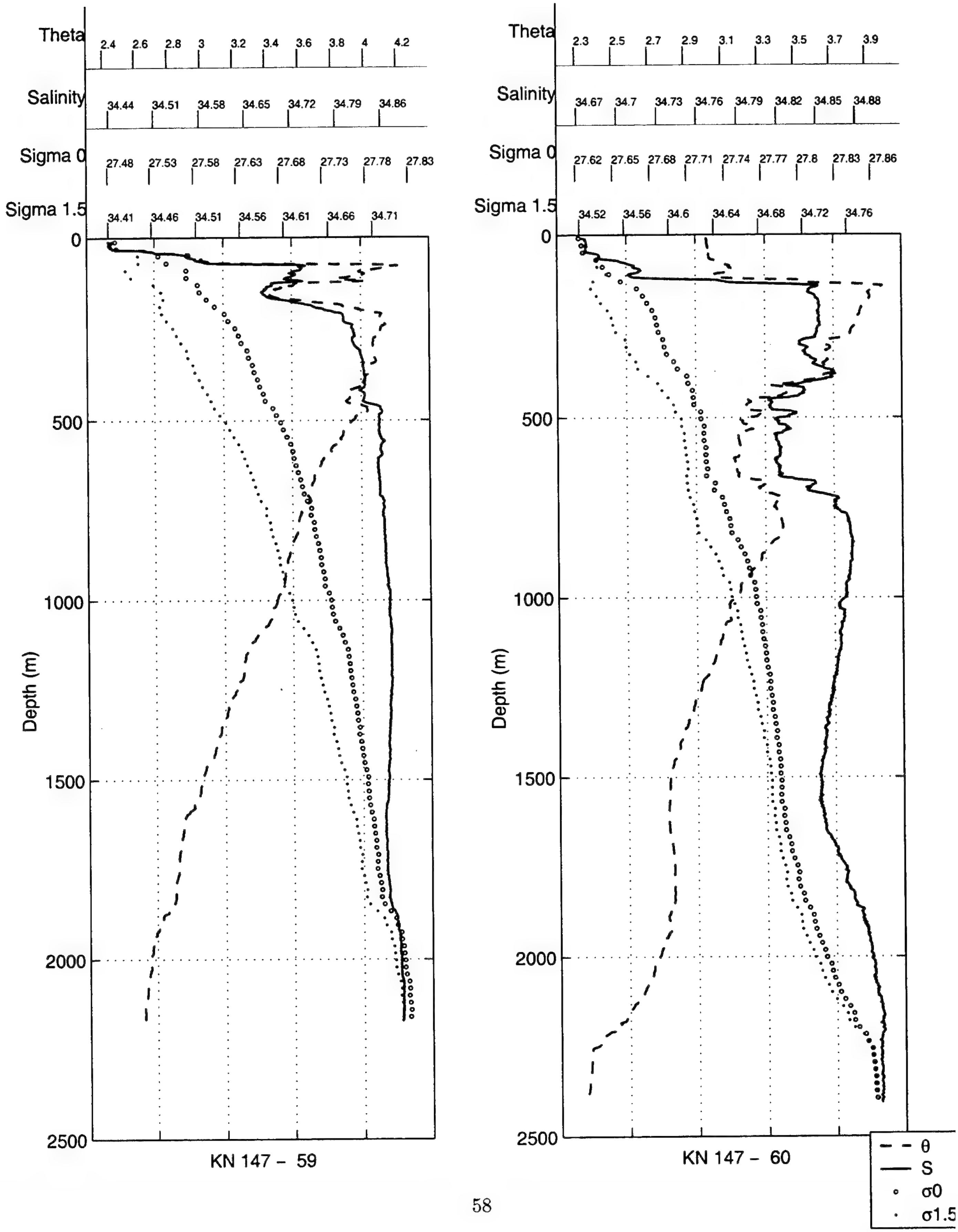
Theta
1.7 1.9 2.1 2.3 2.5 2.7 2.9 3.1 3.3 3.5
Salinity
34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.71 27.74 27.77 27.8 27.83 27.86 27.89
Sigma 1.5
34.6 34.64 34.68 34.72 34.76 34.8 34.84
Depth (m)
0 500 1000 1500 2000 2500 3000
KN 147 - 51
Theta
1.9 2.1 2.3 2.5 2.7 2.9 3.1 3.3
Salinity
34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.71 27.73 27.75 27.77 27.79 27.81 27.83 27.85 27.87 27.89
Sigma 1.5
34.6 34.63 34.66 34.69 34.72 34.75 34.78 34.81 34.84
Depth (m)
0 500 1000 1500 2000 2500 3000
KN 147 - 52
θ
S
σ0
σ1.5

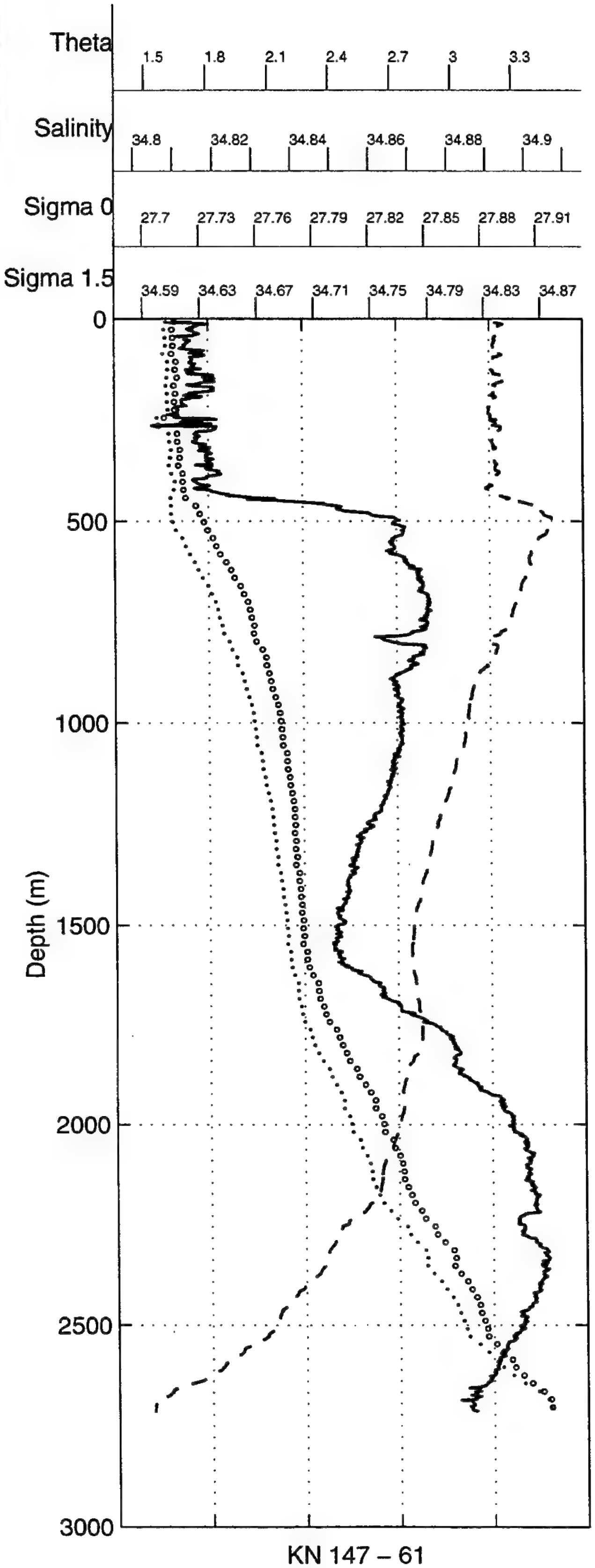

Theta
2 2.2 2.4 2.6 2.8 3 3.2 3.4
Salinity
34.78 34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.7 27.72 27.74 27.76 27.78 27.8 27.82 27.84 27.86 27.88
Sigma 1.5
34.59 34.62 34.65 34.68 34.71 34.74 34.77 34.8
Depth (m)
0 500 1000 1500 2000 2500
KN 147 – 53


Theta
2.3 2.5 2.7 2.9 3.1 3.3 3.5 3.7
Salinity
34.6 34.64 34.68 34.72 34.76 34.8 34.84 34.88
Sigma 0
27.6 27.64 27.68 27.72 27.76 27.8 27.84
Sigma 1.5
34.52 34.56 34.6 34.64 34.68 34.72 34.76
Depth (m)
0 500 1000 1500 2000 2500
KN 147 – 54
θ
S
σ0
σ1.5

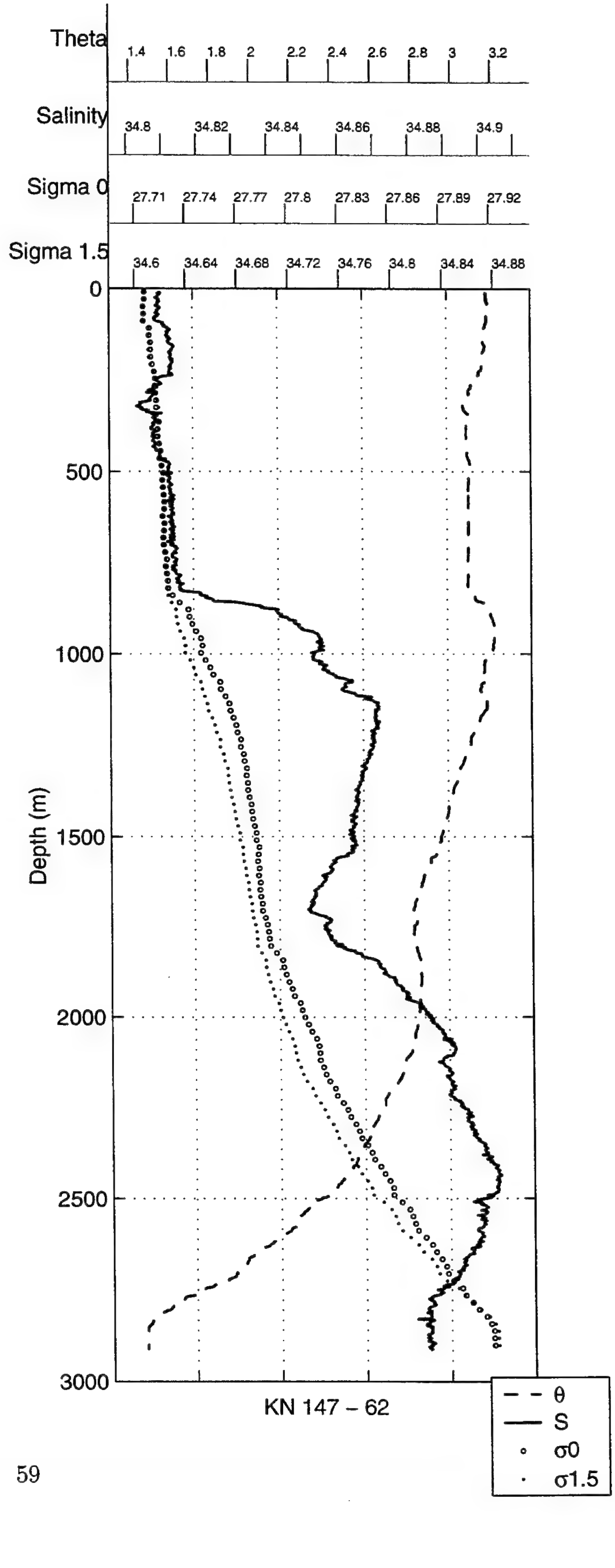

Theta
2.6 2.7 2.8 2.9 3 3.1 3.2 3.3 3.4 3.5 3.6
Salinity
34.74 34.76 34.78 34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.67 27.69 27.71 27.73 27.75 27.77 27.79 27.81 27.83
Sigma 1.5
34.57 34.59 34.61 34.63 34.65 34.67 34.69 34.71 34.73 34.75
Depth (m)
0 200 400 600 800 1000 1200 1400 1600 1800 2000
KN 147 - 55
Theta
2.6 2.8 3 3.2 3.4 3.6 3.8 4
Salinity
34.65 34.68 34.71 34.74 34.77 34.8 34.83 34.86 34.89
Sigma 0
27.63 27.66 27.69 27.72 27.75 27.78 27.81
Sigma 1.5
34.5 34.53 34.56 34.59 34.62 34.65 34.68 34.71
Depth (m)
0 200 400 600 800 1000 1200 1400 1600 1800
KN 147 - 56
θ
S
σ0
σ1.5


Theta
-1.2
-0.3
0.6
1.5
2.4
3.3
4.2
Salinity
33.5
33.7
33.9
34.1
34.3
34.5
34.7
34.9
Sigma 0
26.9
27
27.1
27.2
27.3
27.4
27.5
27.6
27.7
27.8
Sigma 1.5
34
34.1
34.2
34.3
34.4
34.5
34.6
34.7
Depth (m)
0
200
400
600
800
1000
1200
1400
1600
1800
KN 147 - 57
Theta
-1.1
-0.3
0.5
1.3
2.1
2.9
3.7
Salinity
33.5
33.7
33.9
34.1
34.3
34.5
34.7
34.9
Sigma 0
26.9
27
27.1
27.2
27.3
27.4
27.5
27.6
27.7
27.8
Sigma 1.5
34.08
34.17
34.26
34.35
34.44
34.53
34.62
Depth (m)
0
200
400
600
800
1000
1200
1400
1600
KN 147 - 58
θ
S
σ0
σ1.5

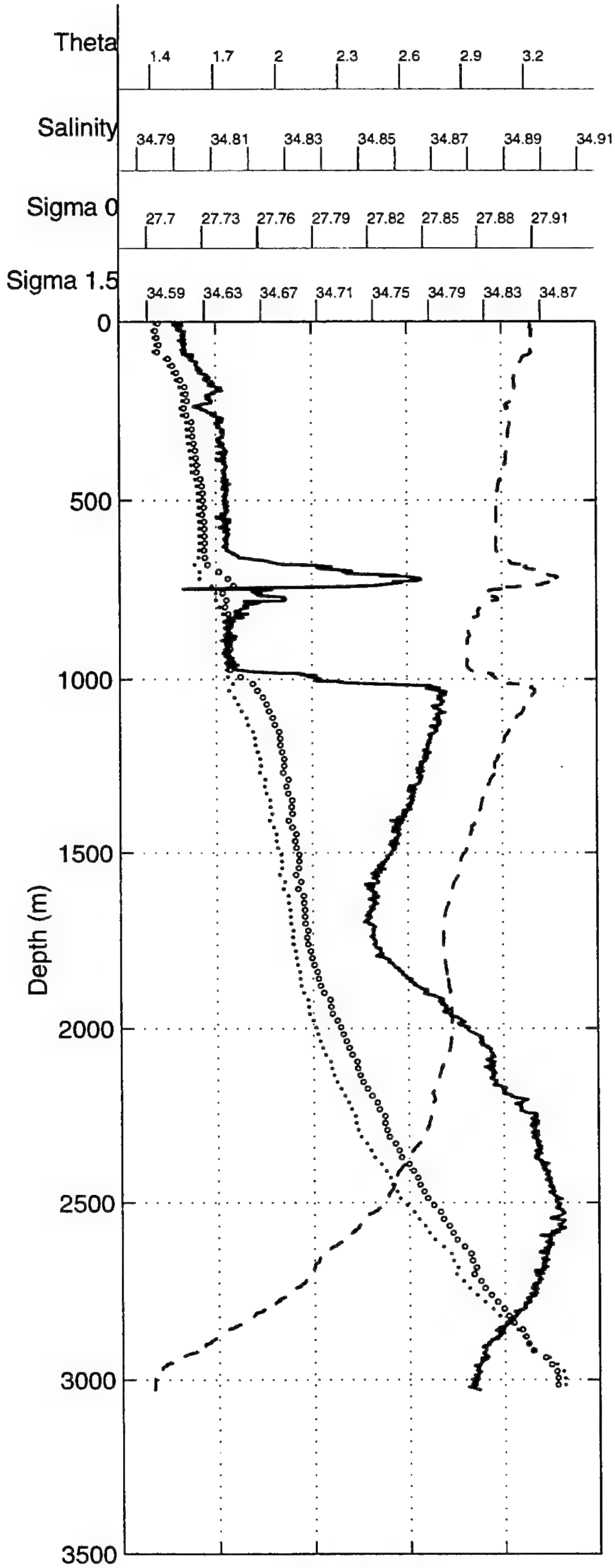

Theta
2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2
Salinity
34.44 34.51 34.58 34.65 34.72 34.79 34.86
Sigma 0
27.48 27.53 27.58 27.63 27.68 27.73 27.78 27.83
Sigma 1.5
34.41 34.46 34.51 34.56 34.61 34.66 34.71
0 500 1000 1500 2000 2500
Depth (m)
KN 147 - 59
Theta
2.3 2.5 2.7 2.9 3.1 3.3 3.5 3.7 3.9
Salinity
34.67 34.7 34.73 34.76 34.79 34.82 34.85 34.88
Sigma 0
27.62 27.65 27.68 27.71 27.74 27.77 27.8 27.83 27.86
Sigma 1.5
34.52 34.56 34.6 34.64 34.68 34.72 34.76
0 500 1000 1500 2000 2500
Depth (m)
KN 147 - 60
θ
S
σ0
σ1.5



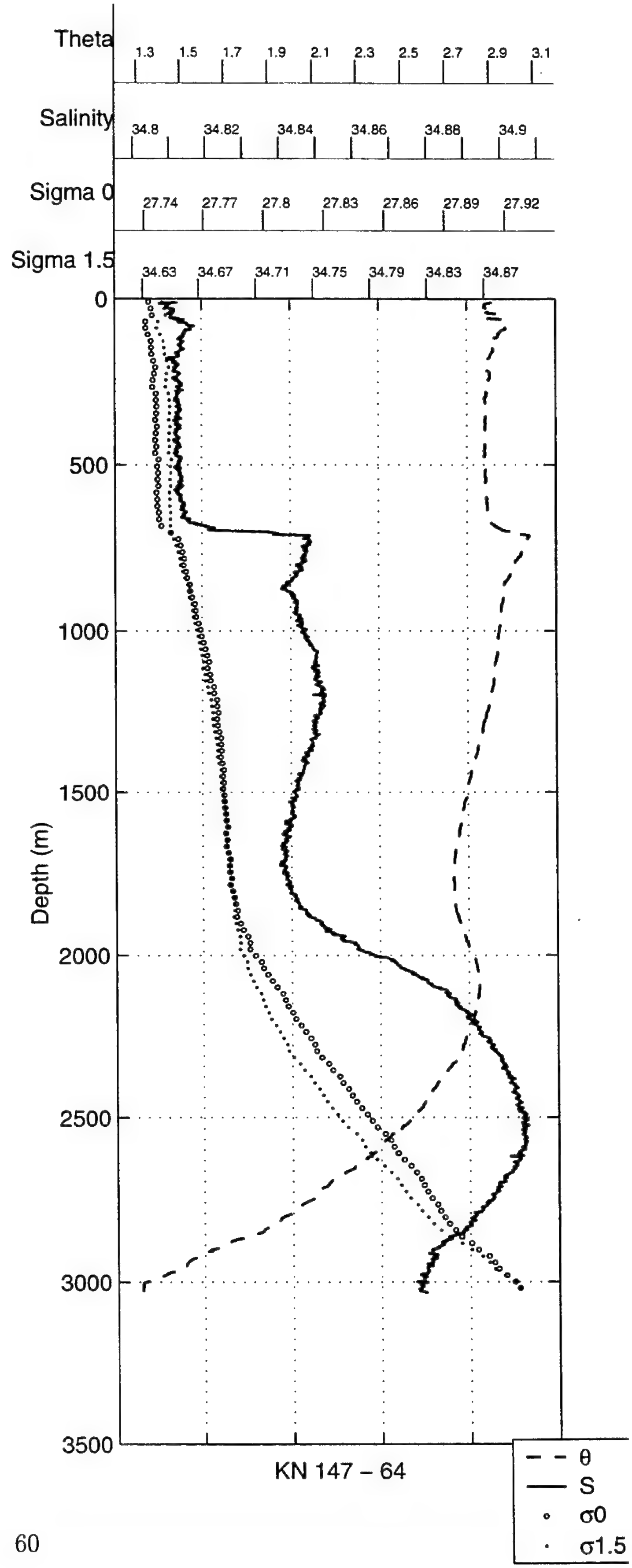
Theta
1.5
1.8
2.1
2.4
2.7
3
3.3
Salinity
34.8
34.82
34.84
34.86
34.88
34.9
Sigma 0
27.7
27.73
27.76
27.79
27.82
27.85
27.88
27.91
Sigma 1.5
34.59
34.63
34.67
34.71
34.75
34.79
34.83
34.87
0
500
1000
1500
2000
2500
3000
Depth (m)
KN 147 – 61



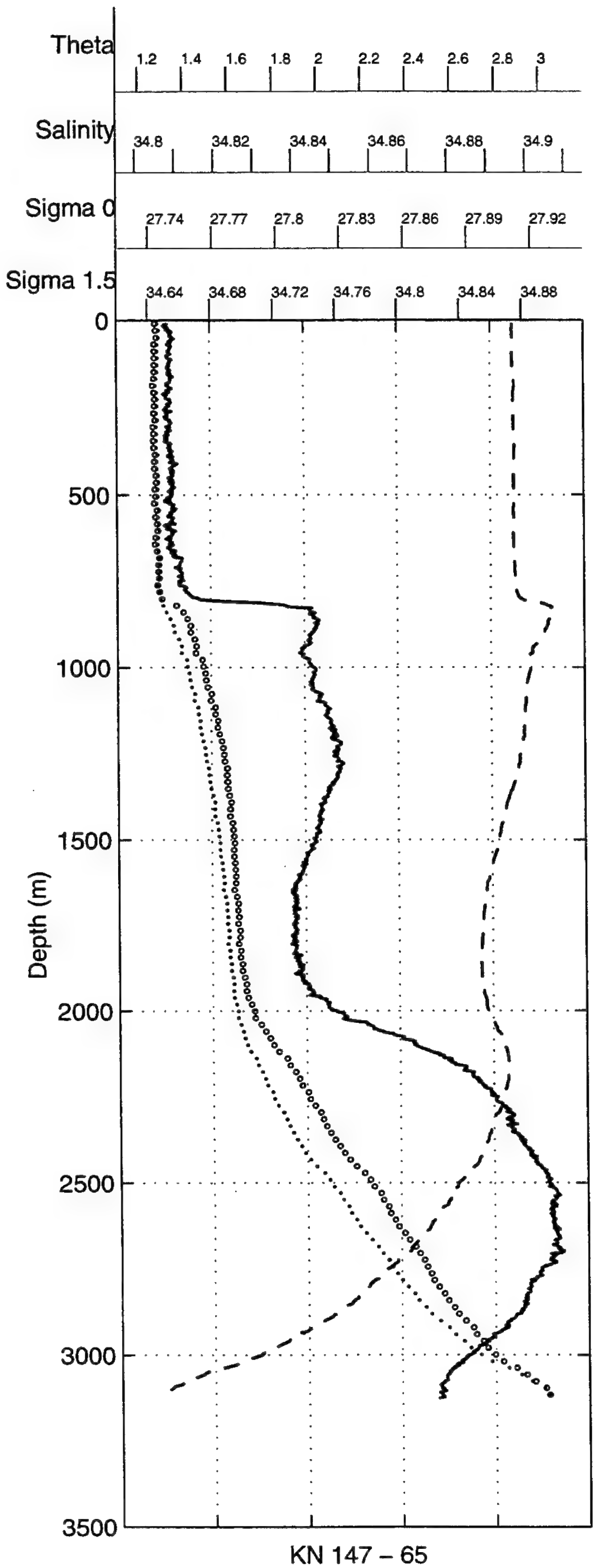
Theta
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
Salinity
34.8
34.82
34.84
34.86
34.88
34.9
Sigma 0
27.71
27.74
27.77
27.8
27.83
27.86
27.89
27.92
Sigma 1.5
34.6
34.64
34.68
34.72
34.76
34.8
34.84
34.88
0
500
1000
1500
2000
2500
3000
Depth (m)
KN 147 – 62
θ
S
σ0
σ1.5



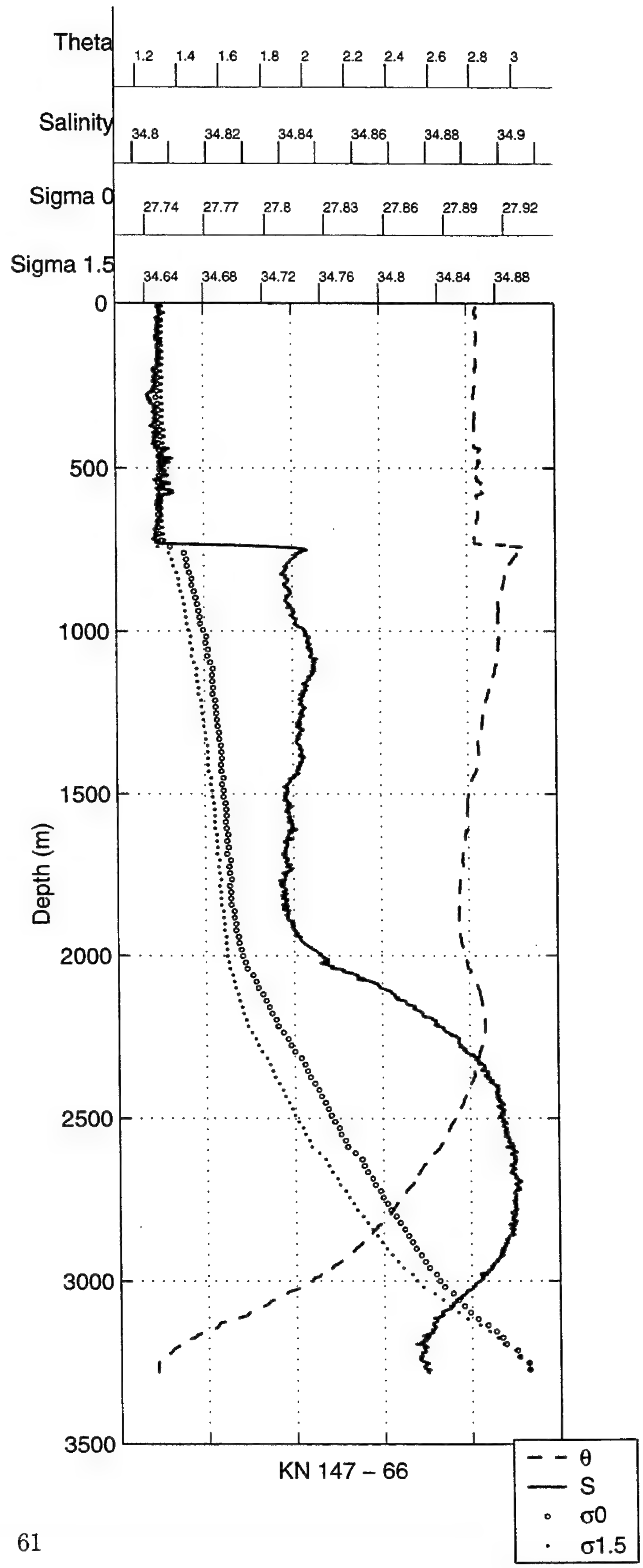
KN 147 – 63



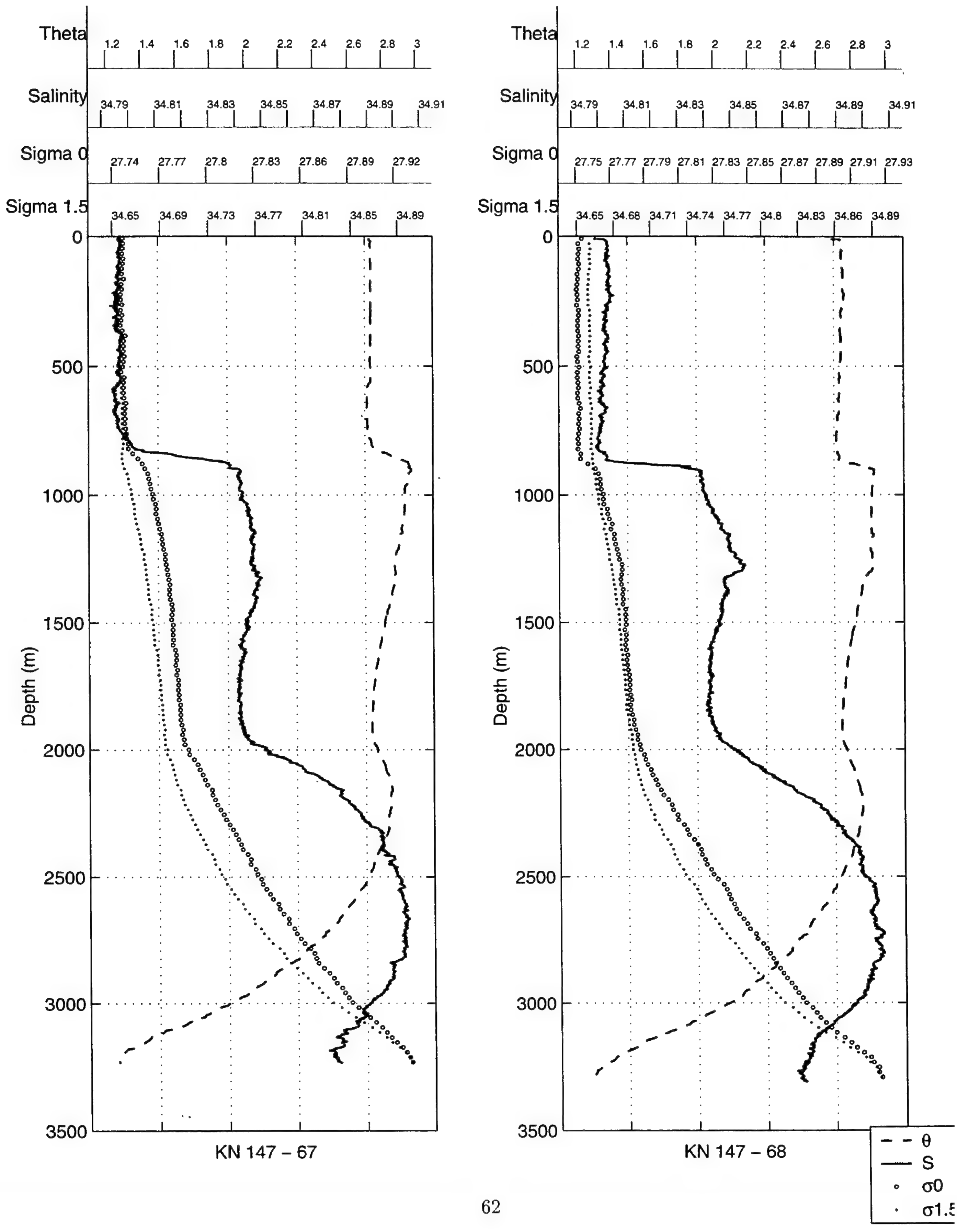
KN 147 – 64

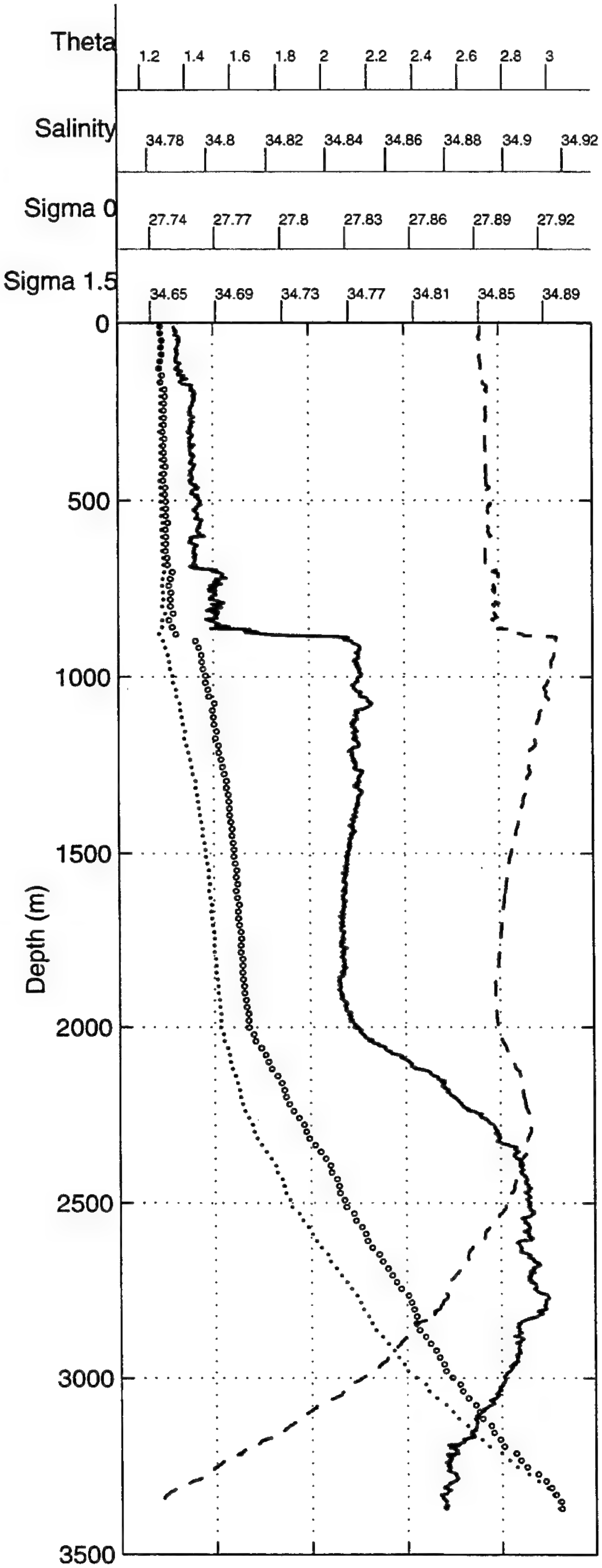


Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.74 27.77 27.8 27.83 27.86 27.89 27.92
Sigma 1.5
34.64 34.68 34.72 34.76 34.8 34.84 34.88
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 65

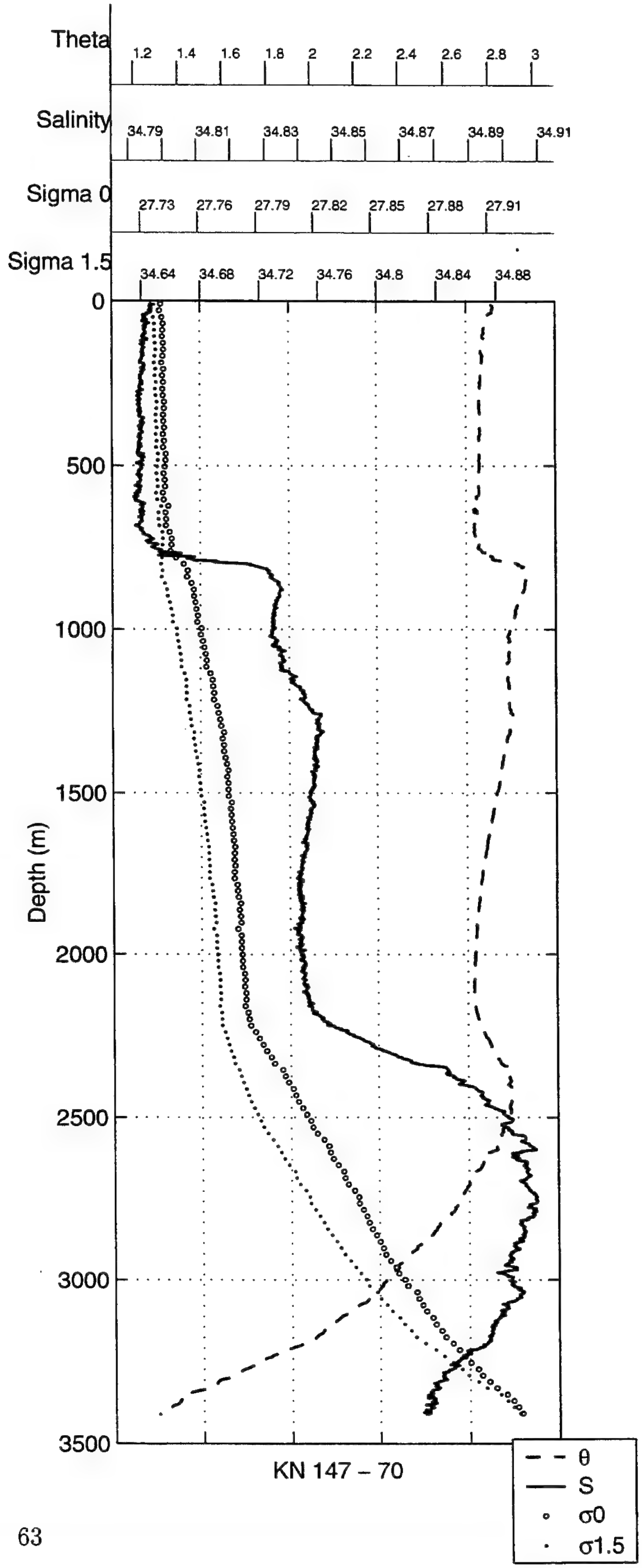


Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.74 27.77 27.8 27.83 27.86 27.89 27.92
Sigma 1.5
34.64 34.68 34.72 34.76 34.8 34.84 34.88
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 66
θ
S
σ0
σ1.5

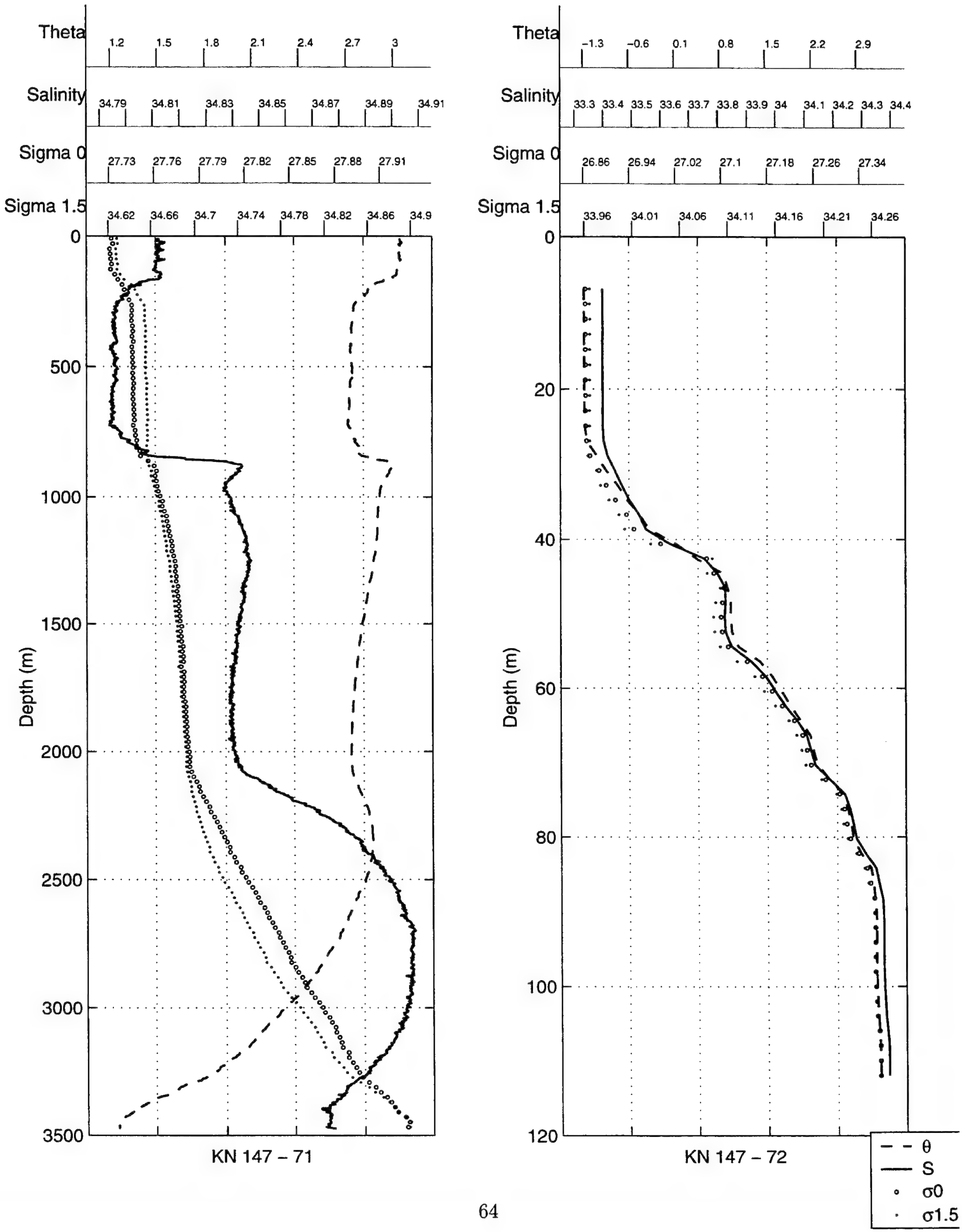

Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.74 27.77 27.8 27.83 27.86 27.89 27.92
Sigma 1.5
34.65 34.69 34.73 34.77 34.81 34.85 34.89
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 67
Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.75 27.77 27.79 27.81 27.83 27.85 27.87 27.89 27.91 27.93
Sigma 1.5
34.65 34.68 34.71 34.74 34.77 34.8 34.83 34.86 34.89
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 68
θ
S
σ0
σ1.5



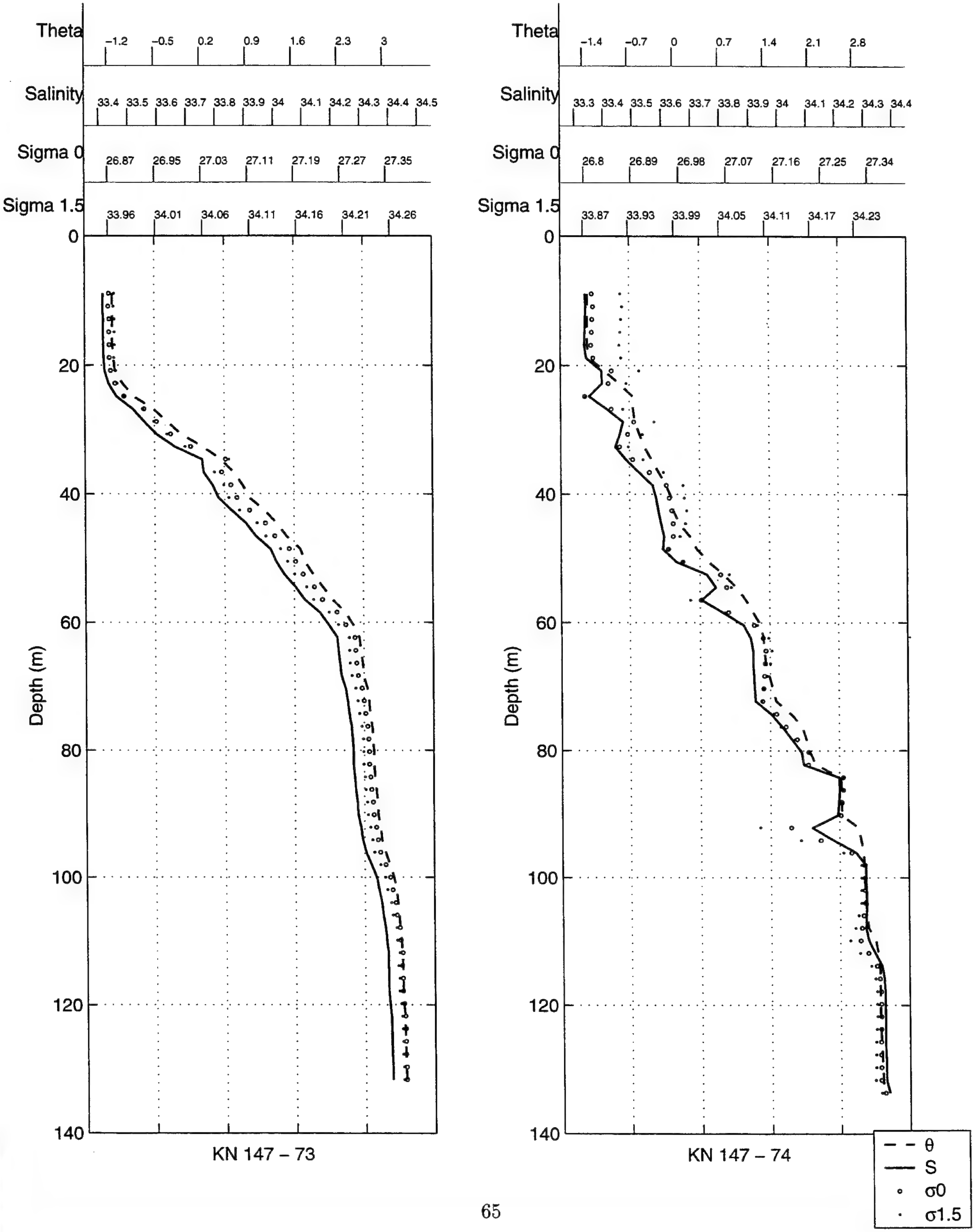
KN 147 – 69

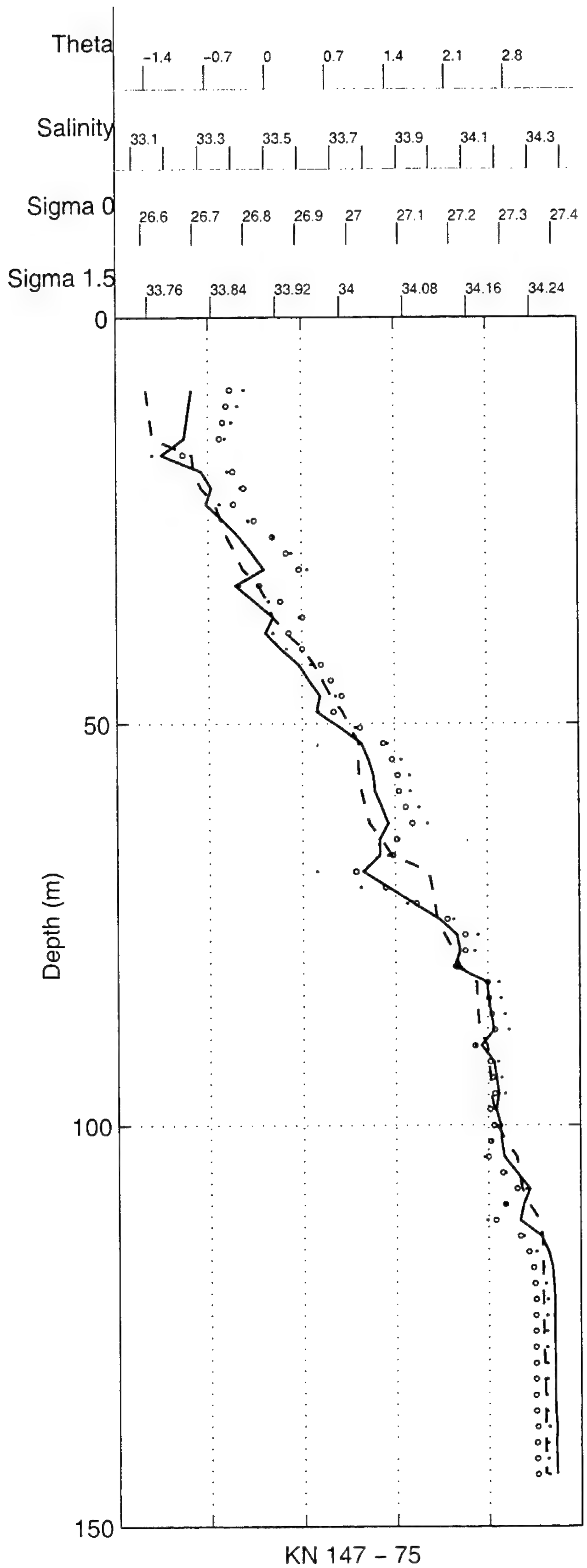


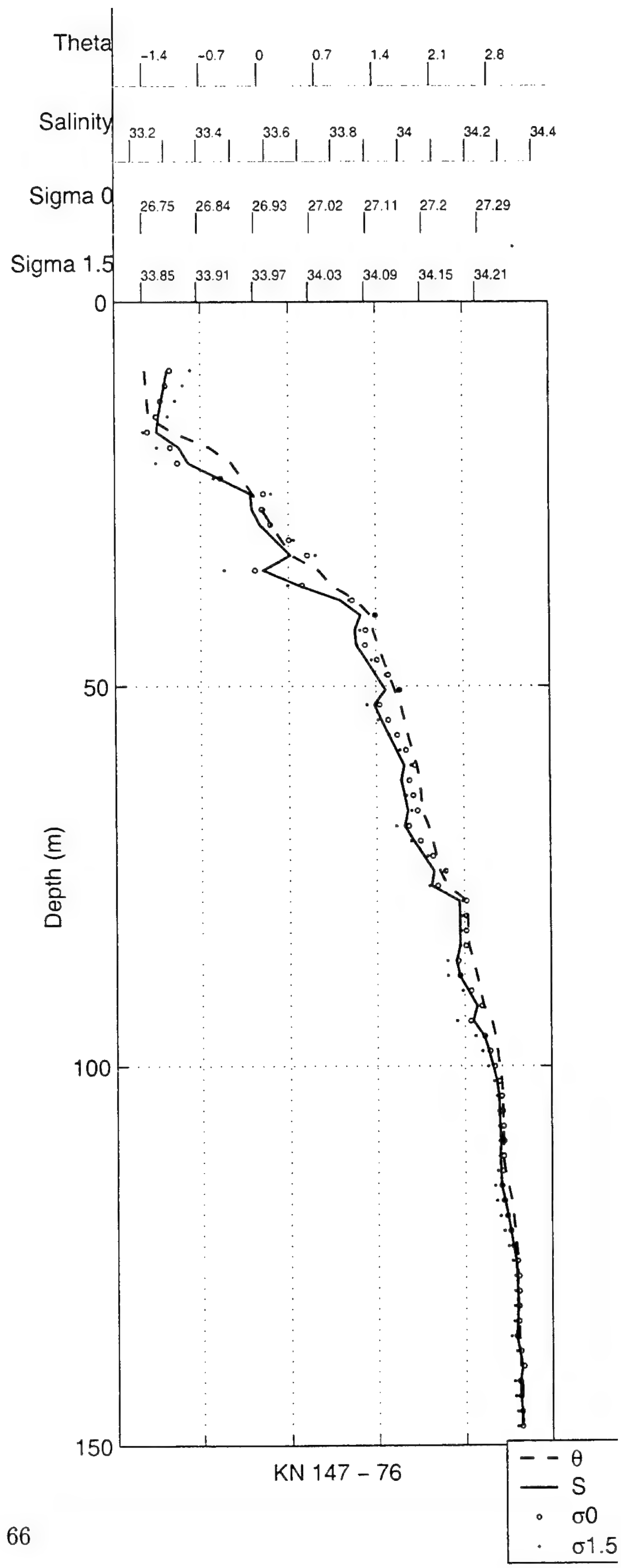
KN 147 – 70

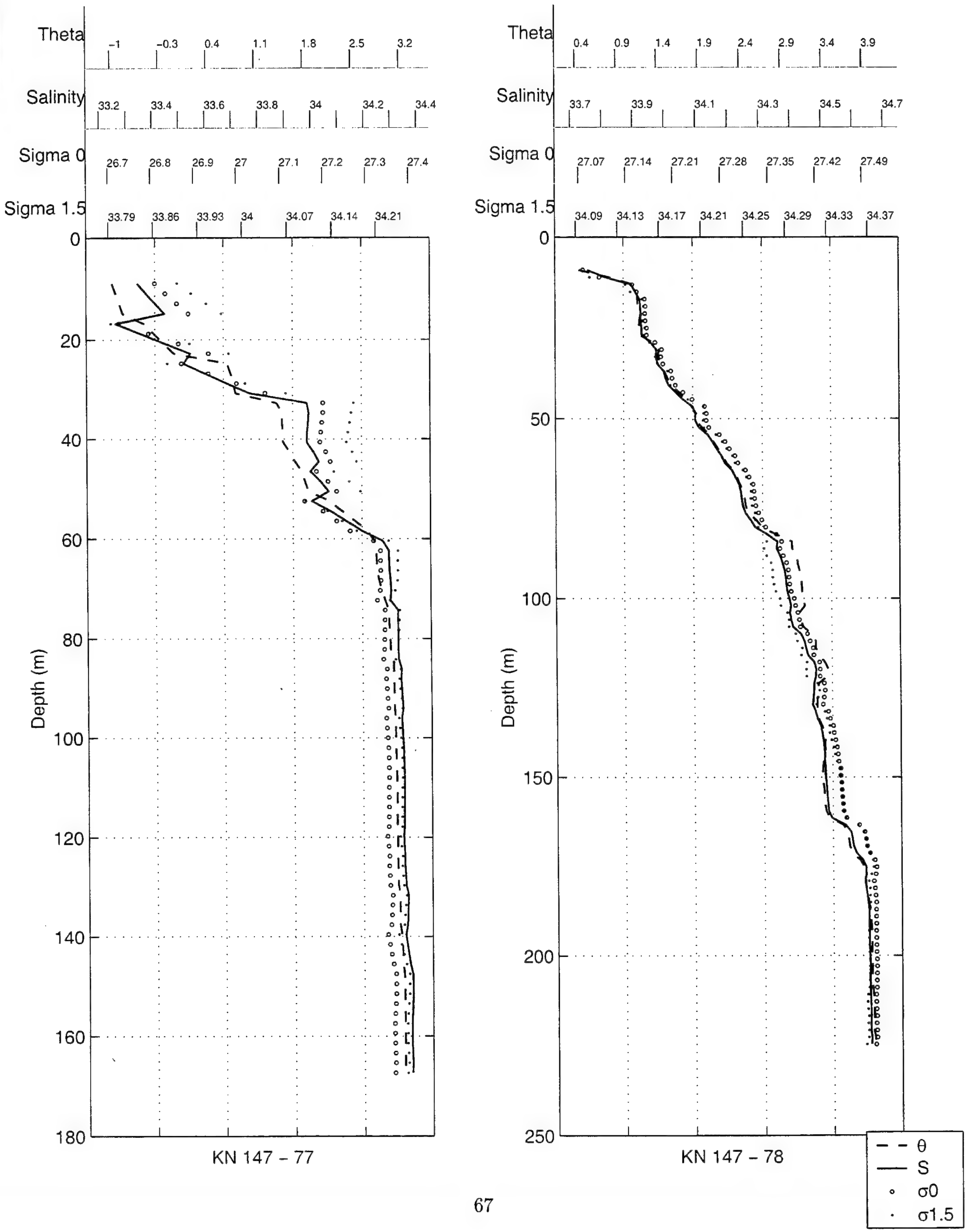


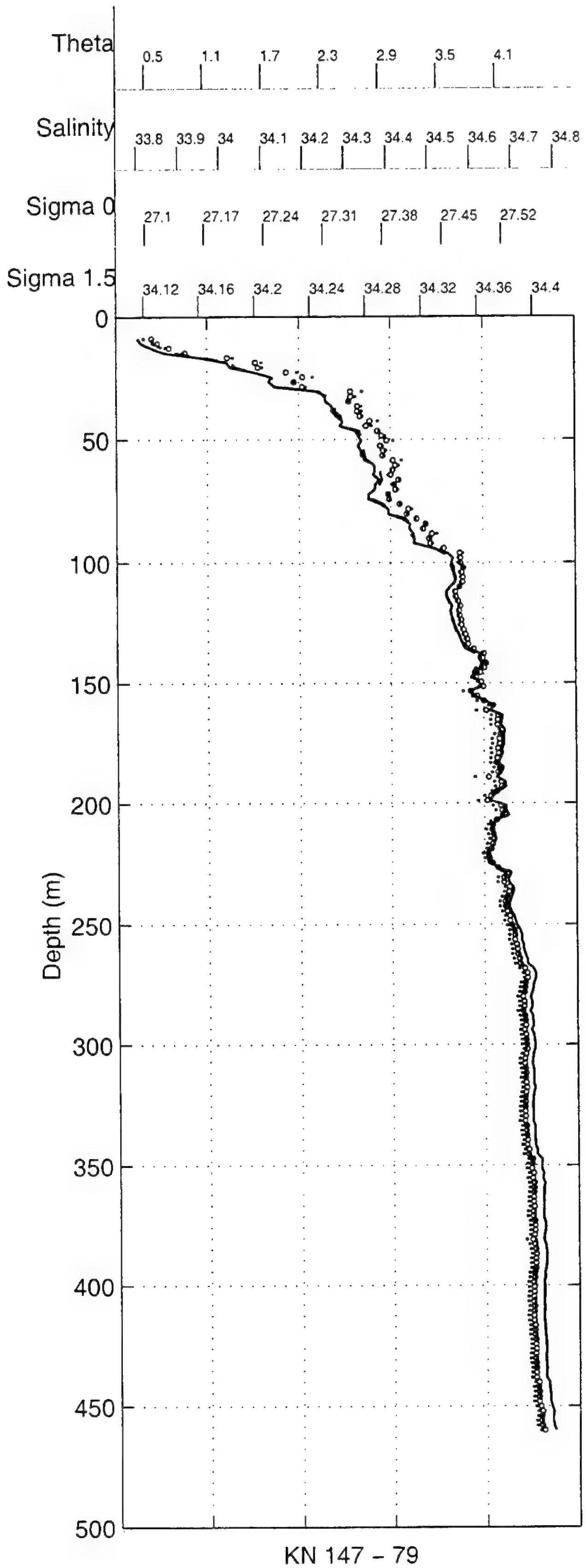
Theta
1.2 1.5 1.8 2.1 2.4 2.7 3
Salinity
34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.73 27.76 27.79 27.82 27.85 27.88 27.91
Sigma 1.5
34.62 34.66 34.7 34.74 34.78 34.82 34.86 34.9
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 71
Theta
-1.3 -0.6 0.1 0.8 1.5 2.2 2.9
Salinity
33.3 33.4 33.5 33.6 33.7 33.8 33.9 34 34.1 34.2 34.3 34.4
Sigma 0
26.86 26.94 27.02 27.1 27.18 27.26 27.34
Sigma 1.5
33.96 34.01 34.06 34.11 34.16 34.21 34.26
Depth (m)
0 20 40 60 80 100 120
KN 147 – 72
θ
S
σ0
σ1.5

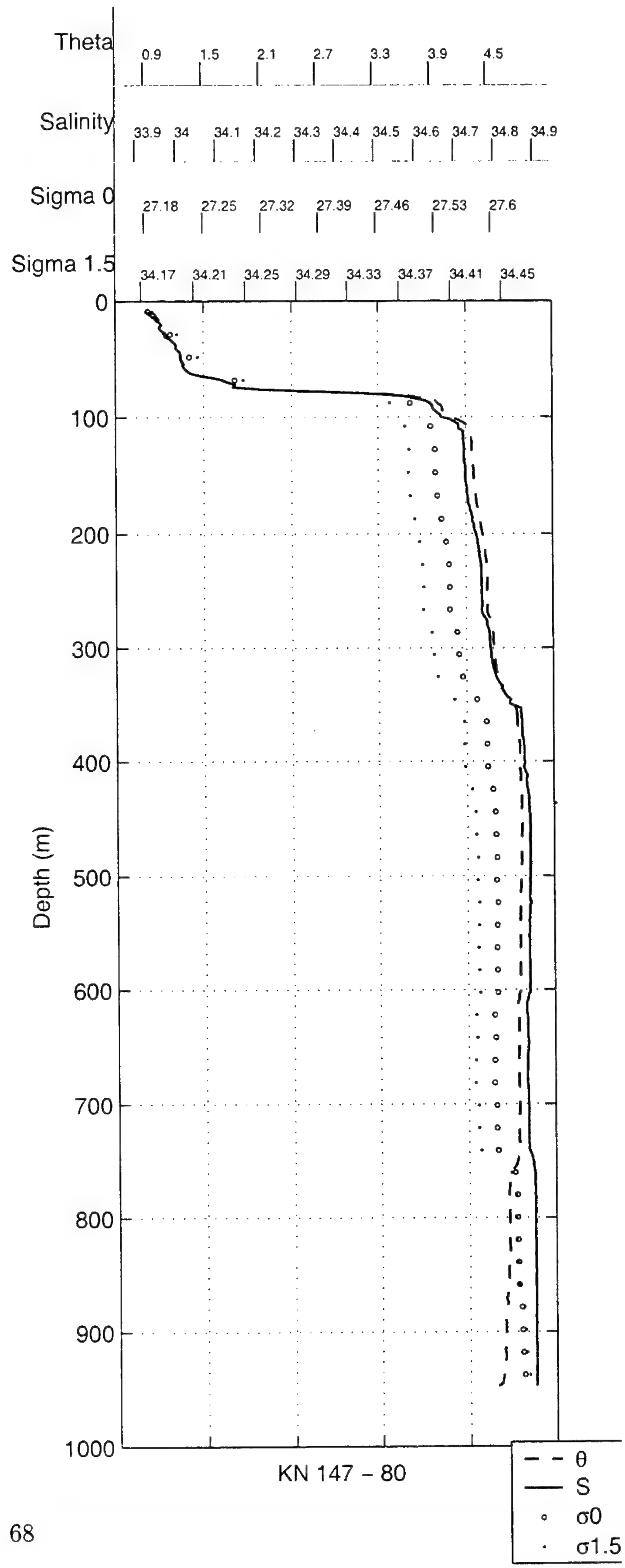

Theta
-1.2 -0.5 0.2 0.9 1.6 2.3 3
Salinity
33.4 33.5 33.6 33.7 33.8 33.9 34 34.1 34.2 34.3 34.4 34.5
Sigma 0
26.87 26.95 27.03 27.11 27.19 27.27 27.35
Sigma 1.5
33.96 34.01 34.06 34.11 34.16 34.21 34.26
Depth (m)
0 20 40 60 80 100 120 140
KN 147 – 73
Theta
-1.4 -0.7 0 0.7 1.4 2.1 2.8
Salinity
33.3 33.4 33.5 33.6 33.7 33.8 33.9 34 34.1 34.2 34.3 34.4
Sigma 0
26.8 26.89 26.98 27.07 27.16 27.25 27.34
Sigma 1.5
33.87 33.93 33.99 34.05 34.11 34.17 34.23
Depth (m)
0 20 40 60 80 100 120 140
KN 147 – 74
θ
S
σ0
σ1.5

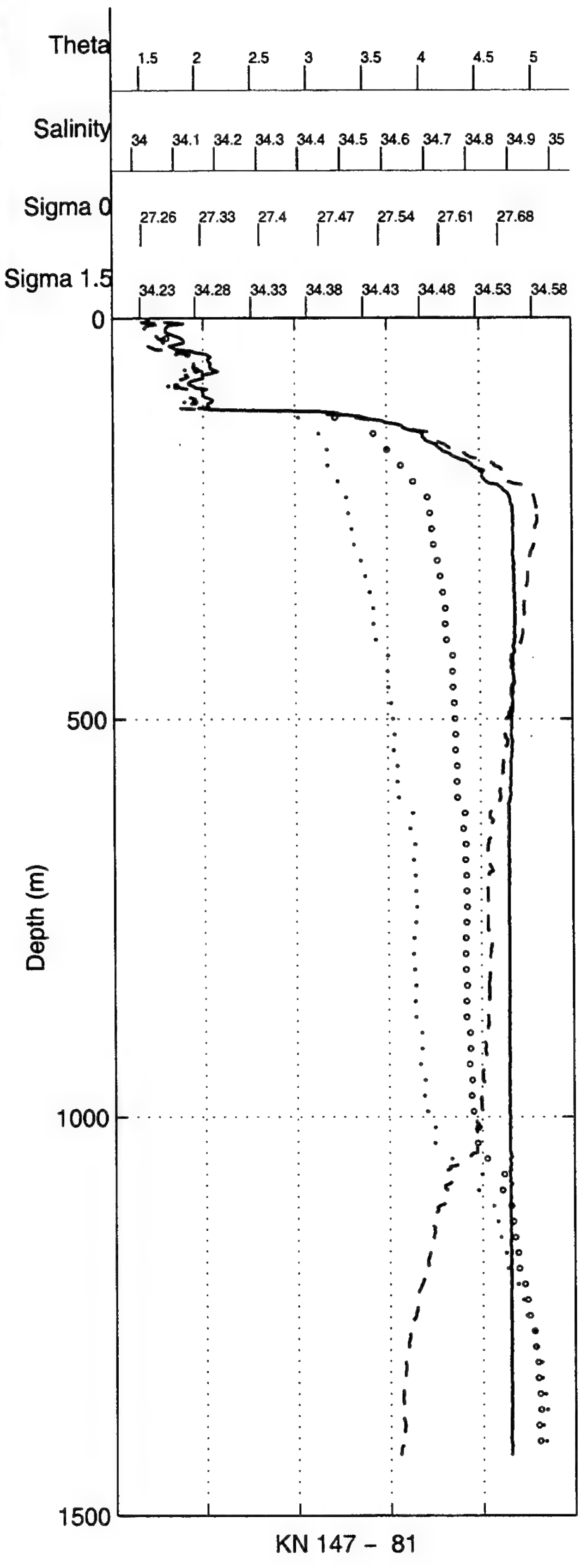

Theta
-1.4
-0.7
0
0.7
1.4
2.1
2.8
Salinity
33.1
33.3
33.5
33.7
33.9
34.1
34.3
Sigma 0
26.6
26.7
26.8
26.9
27
27.1
27.2
27.3
27.4
Sigma 1.5
33.76
33.84
33.92
34
34.08
34.16
34.24
0
50
100
150
Depth (m)
KN 147 - 75


Theta
-1.4
-0.7
0
0.7
1.4
2.1
2.8
Salinity
33.2
33.4
33.6
33.8
34
34.2
34.4
Sigma 0
26.75
26.84
26.93
27.02
27.11
27.2
27.29
Sigma 1.5
33.85
33.91
33.97
34.03
34.09
34.15
34.21
0
50
100
150
Depth (m)
KN 147 - 76
θ
S
σ0
σ1.5

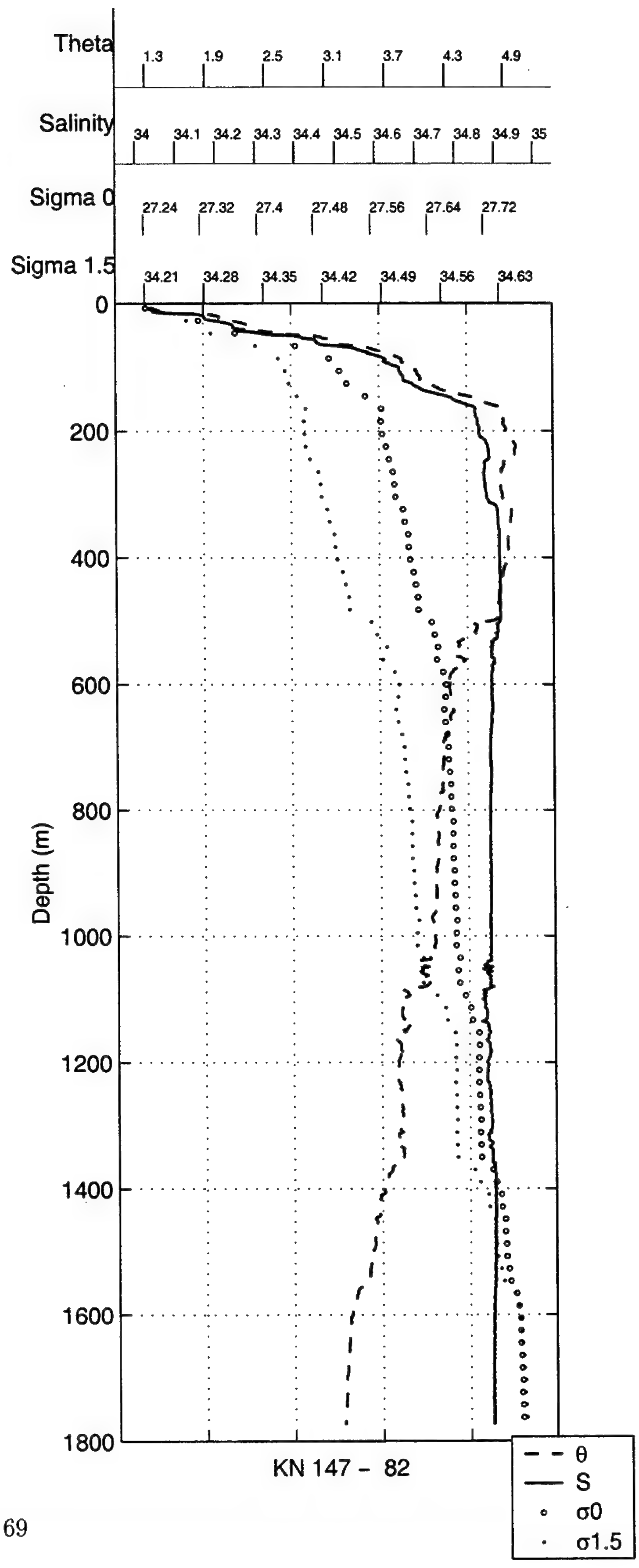

Theta
-1
-0.3
0.4
1.1
1.8
2.5
3.2
Salinity
33.2
33.4
33.6
33.8
34
34.2
34.4
Sigma 0
26.7
26.8
26.9
27
27.1
27.2
27.3
27.4
Sigma 1.5
33.79
33.86
33.93
34
34.07
34.14
34.21
Depth (m)
0
20
40
60
80
100
120
140
160
180
KN 147 - 77
Theta
0.4
0.9
1.4
1.9
2.4
2.9
3.4
3.9
Salinity
33.7
33.9
34.1
34.3
34.5
34.7
Sigma 0
27.07
27.14
27.21
27.28
27.35
27.42
27.49
Sigma 1.5
34.09
34.13
34.17
34.21
34.25
34.29
34.33
34.37
Depth (m)
0
50
100
150
200
250
KN 147 - 78
θ
S
σ0
σ1.5


Theta
0.5 1.1 1.7 2.3 2.9 3.5 4.1
Salinity
33.8 33.9 34 34.1 34.2 34.3 34.4 34.5 34.6 34.7 34.8
Sigma 0
27.1 27.17 27.24 27.31 27.38 27.45 27.52
Sigma 1.5
34.12 34.16 34.2 34.24 34.28 34.32 34.36 34.4
0 50 100 150 200 250 300 350 400 450 500
Depth (m)
KN 147 – 79

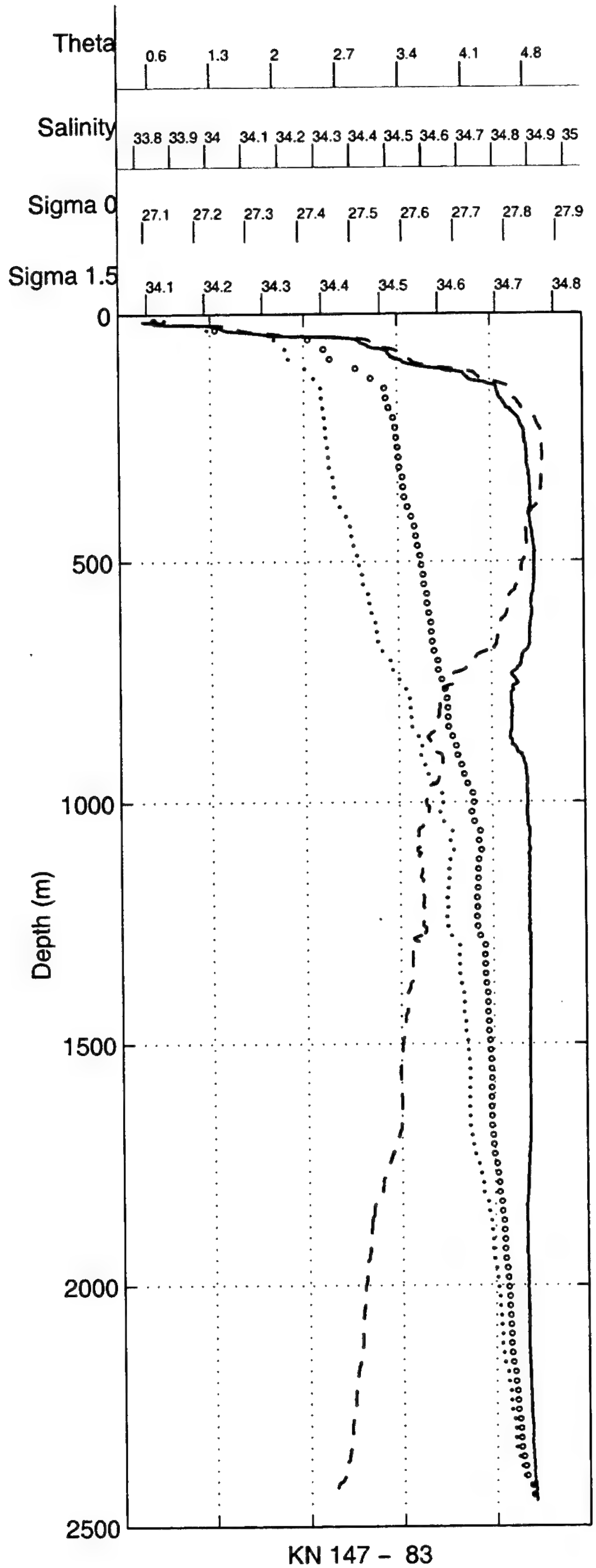

Theta
0.9 1.5 2.1 2.7 3.3 3.9 4.5
Salinity
33.9 34 34.1 34.2 34.3 34.4 34.5 34.6 34.7 34.8 34.9
Sigma 0
27.18 27.25 27.32 27.39 27.46 27.53 27.6
Sigma 1.5
34.17 34.21 34.25 34.29 34.33 34.37 34.41 34.45
0 100 200 300 400 500 600 700 800 900 1000
Depth (m)
KN 147 – 80
θ
S
σ0
σ1.5



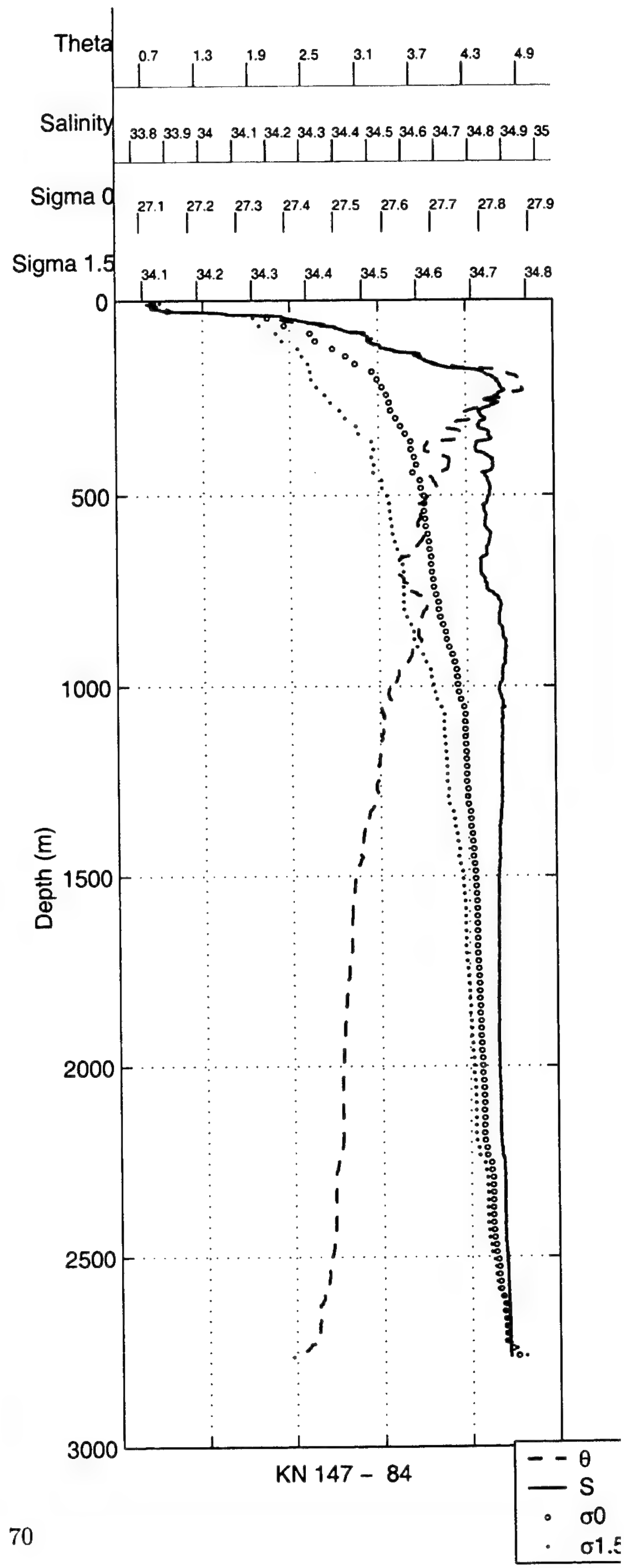
Theta
1.5
2
2.5
3
3.5
4
4.5
5
Salinity
34
34.1
34.2
34.3
34.4
34.5
34.6
34.7
34.8
34.9
35
Sigma 0
27.26
27.33
27.4
27.47
27.54
27.61
27.68
Sigma 1.5
34.23
34.28
34.33
34.38
34.43
34.48
34.53
34.58
Depth (m)
0
500
1000
1500
KN 147 - 81



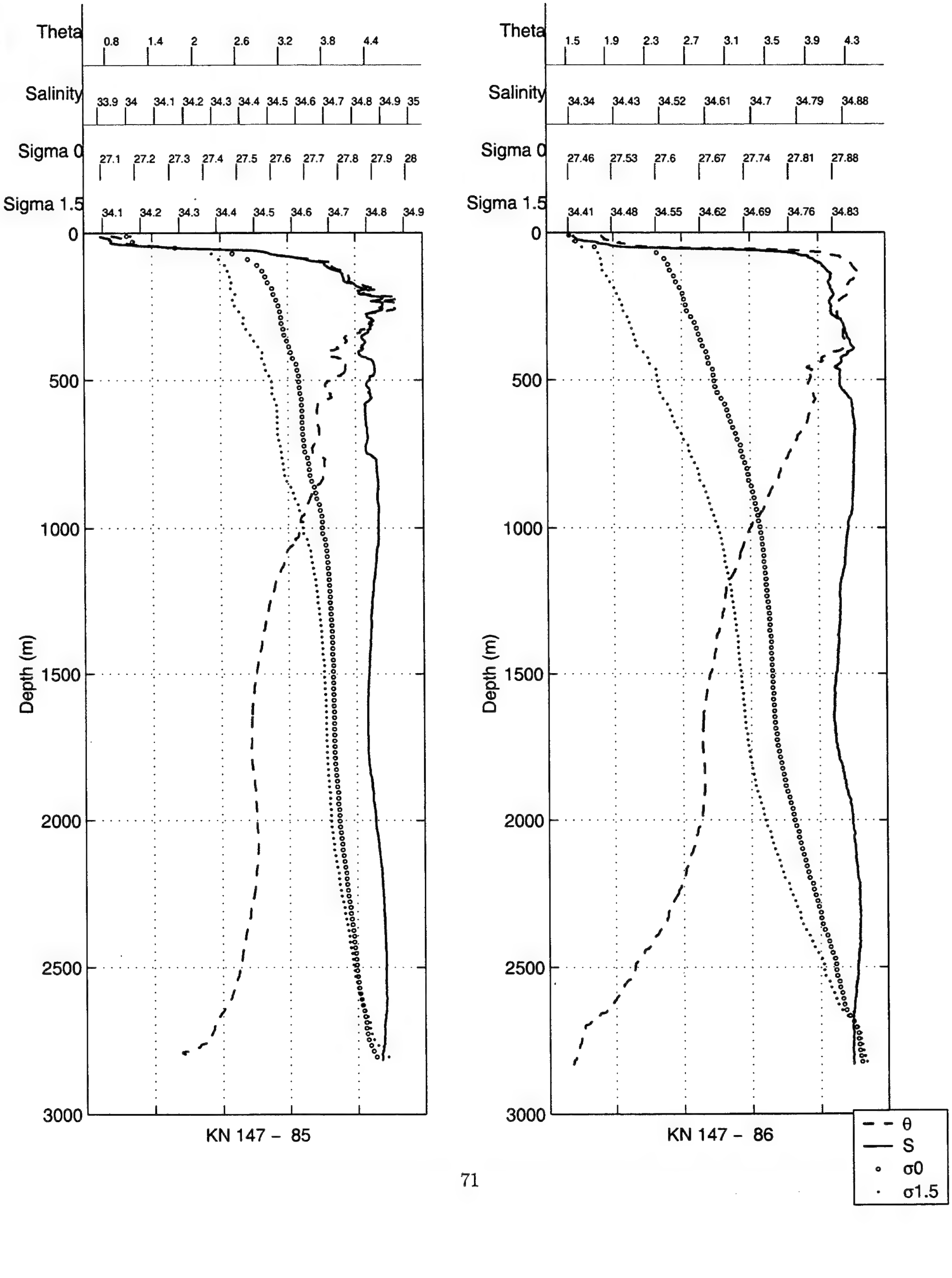
Theta
1.3
1.9
2.5
3.1
3.7
4.3
4.9
Salinity
34
34.1
34.2
34.3
34.4
34.5
34.6
34.7
34.8
34.9
35
Sigma 0
27.24
27.32
27.4
27.48
27.56
27.64
27.72
Sigma 1.5
34.21
34.28
34.35
34.42
34.49
34.56
34.63
Depth (m)
0
200
400
600
800
1000
1200
1400
1600
1800
KN 147 - 82
θ
S
σ0
σ1.5

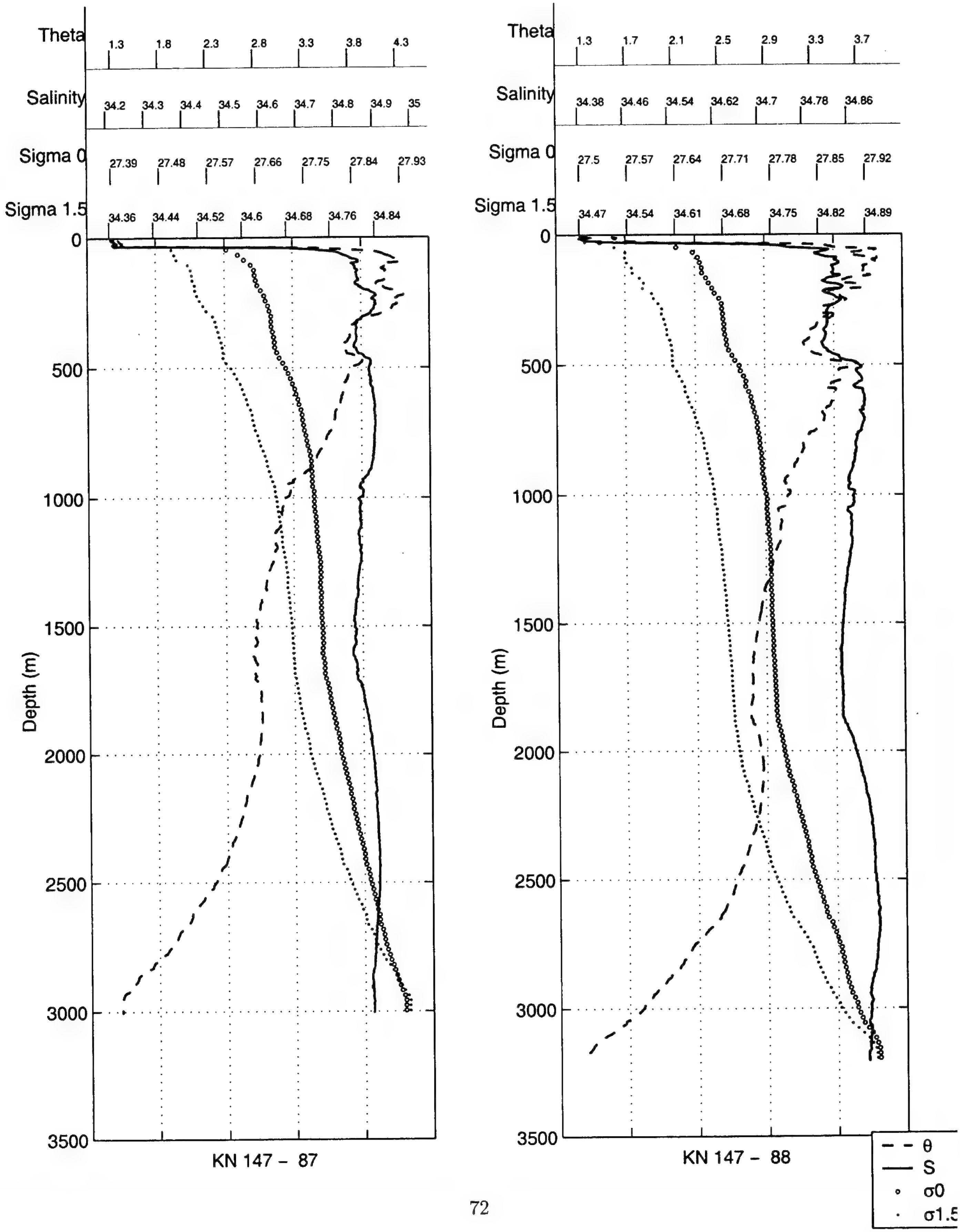


Theta
0.6
1.3
2
2.7
3.4
4.1
4.8
Salinity
33.8 33.9 34 34.1 34.2 34.3 34.4 34.5 34.6 34.7 34.8 34.9 35
Sigma 0
27.1 27.2 27.3 27.4 27.5 27.6 27.7 27.8 27.9
Sigma 1.5
34.1 34.2 34.3 34.4 34.5 34.6 34.7 34.8
0
500
1000
1500
2000
2500
Depth (m)
KN 147 - 83

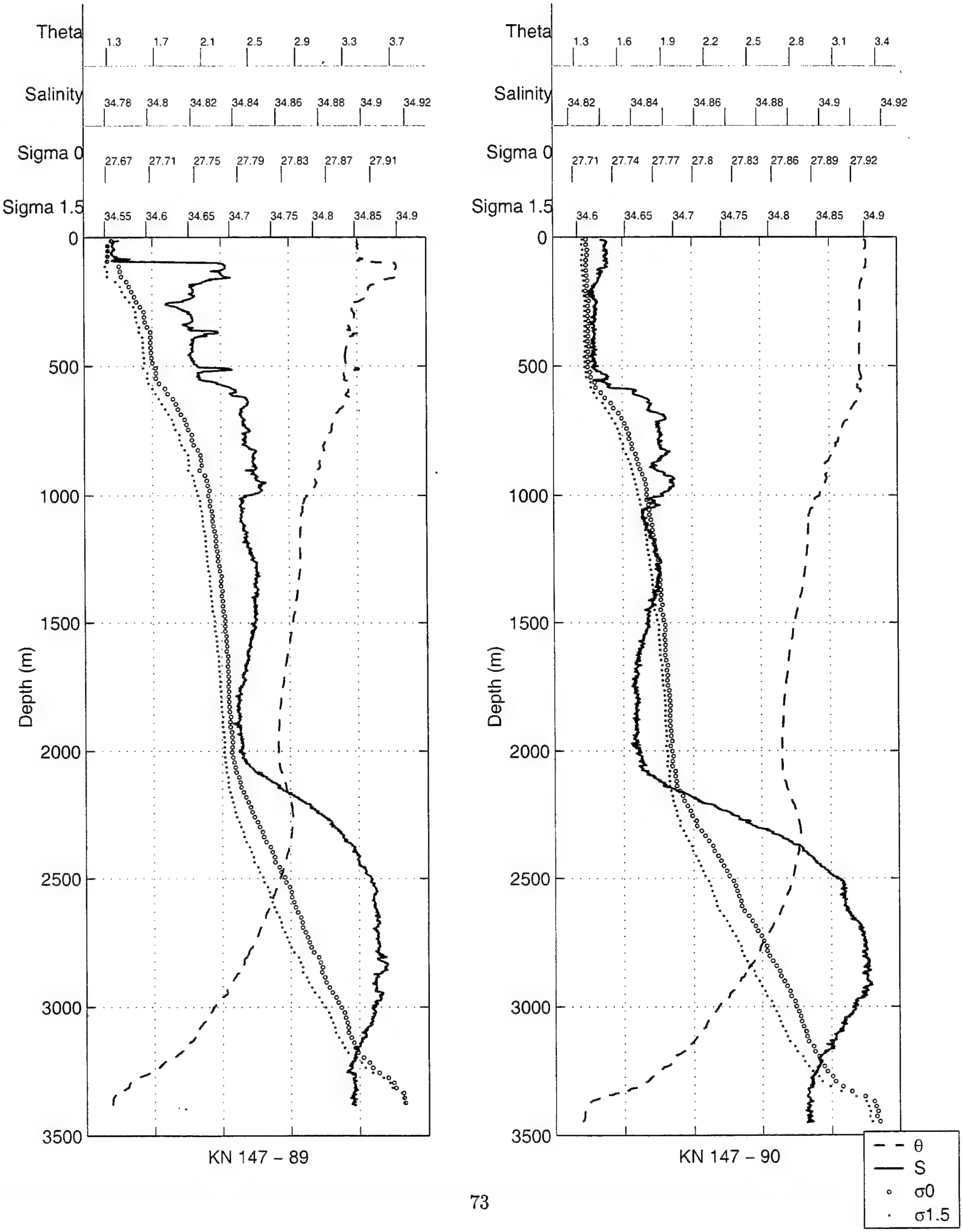


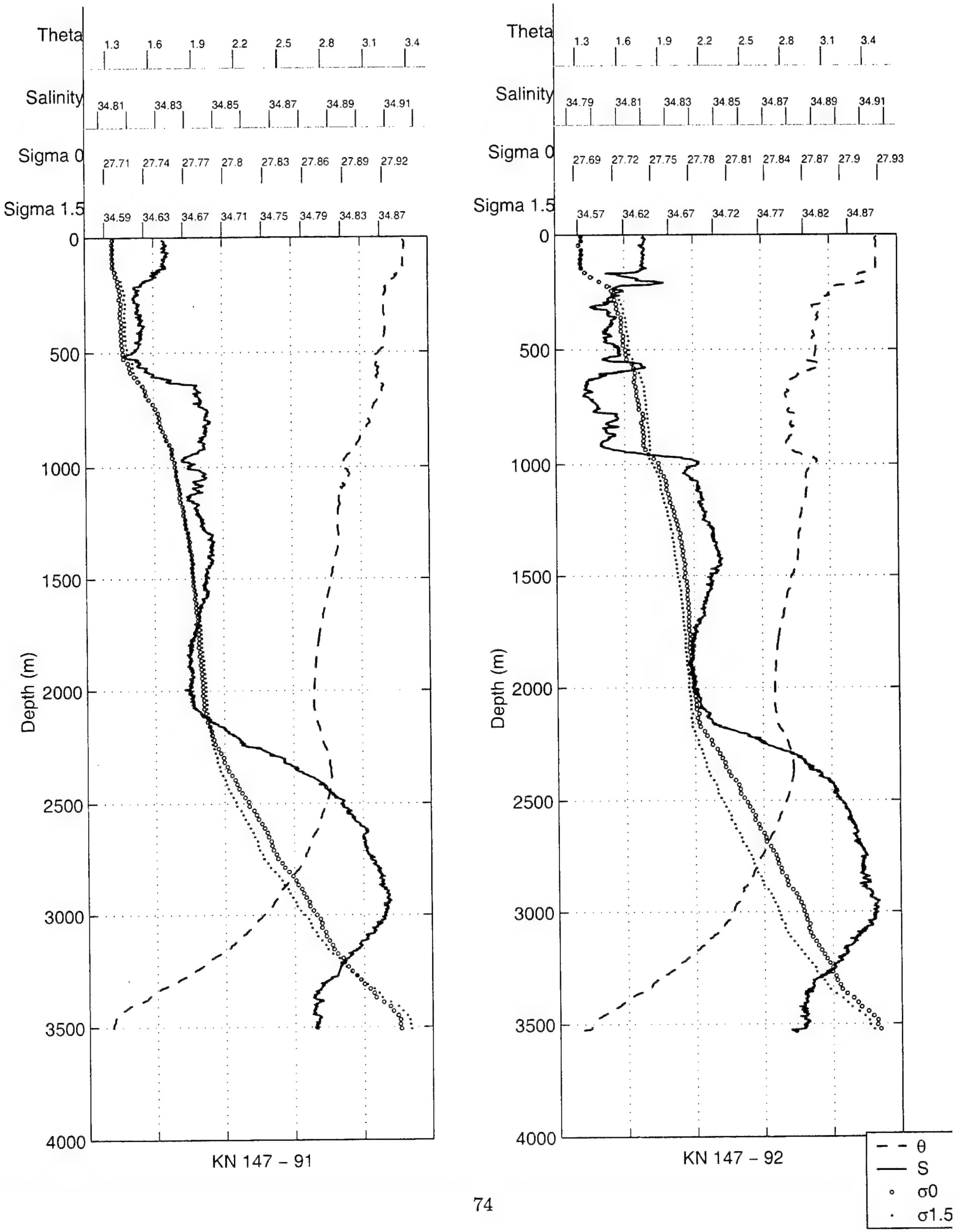
Theta
0.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
Salinity
33.8 33.9 34 34.1 34.2 34.3 34.4 34.5 34.6 34.7 34.8 34.9 35
Sigma 0
27.1 27.2 27.3 27.4 27.5 27.6 27.7 27.8 27.9
Sigma 1.5
34.1 34.2 34.3 34.4 34.5 34.6 34.7 34.8
0
500
1000
1500
2000
2500
3000
Depth (m)
KN 147 - 84
θ
S
σ0
σ1.5

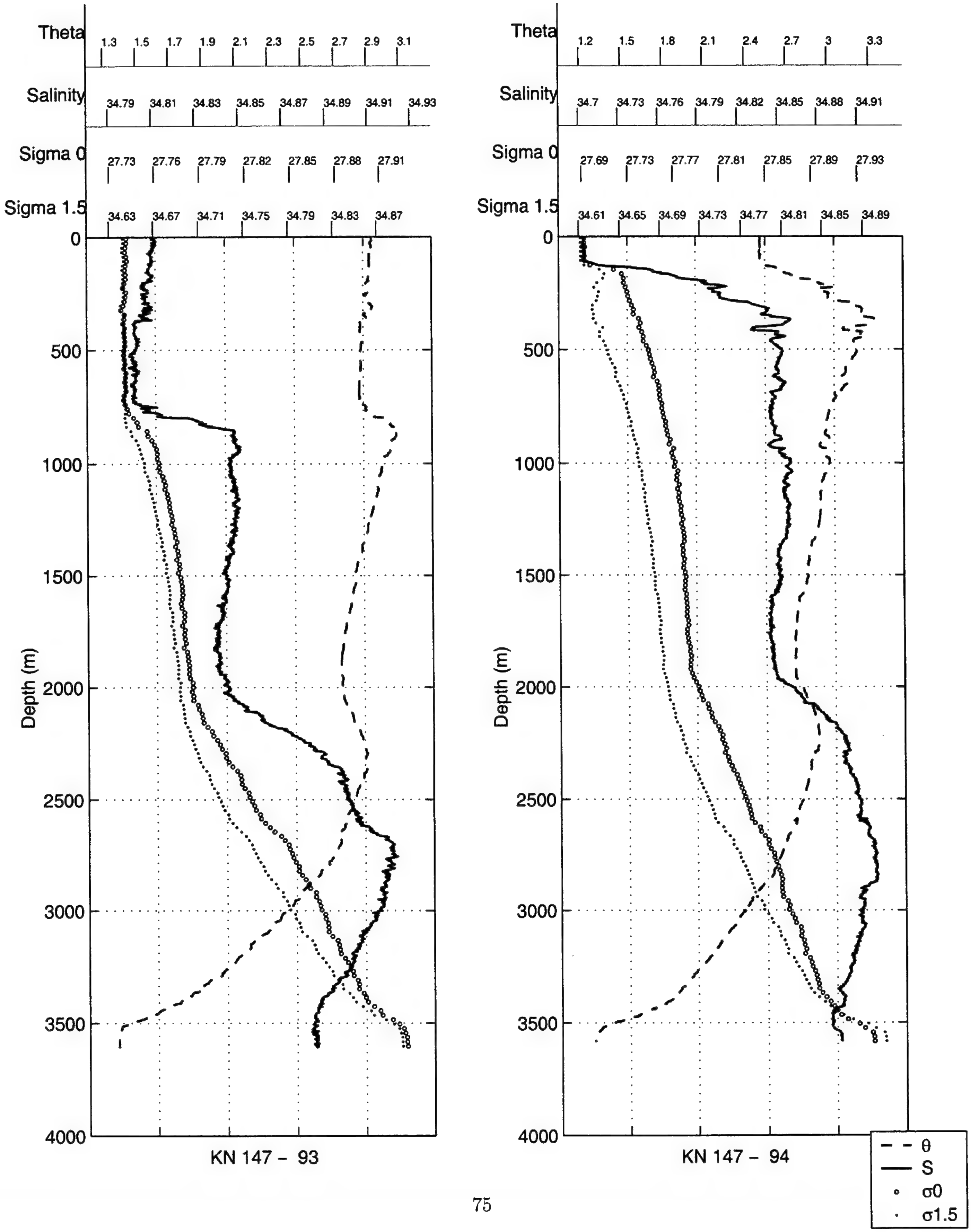

Theta
0.8 1.4 2 2.6 3.2 3.8 4.4
Salinity
33.9 34 34.1 34.2 34.3 34.4 34.5 34.6 34.7 34.8 34.9 35
Sigma 0
27.1 27.2 27.3 27.4 27.5 27.6 27.7 27.8 27.9 28
Sigma 1.5
34.1 34.2 34.3 34.4 34.5 34.6 34.7 34.8 34.9
Depth (m)
0 500 1000 1500 2000 2500 3000
KN 147 - 85
Theta
1.5 1.9 2.3 2.7 3.1 3.5 3.9 4.3
Salinity
34.34 34.43 34.52 34.61 34.7 34.79 34.88
Sigma 0
27.46 27.53 27.6 27.67 27.74 27.81 27.88
Sigma 1.5
34.41 34.48 34.55 34.62 34.69 34.76 34.83
Depth (m)
0 500 1000 1500 2000 2500 3000
KN 147 - 86
θ
S
σ0
σ1.5

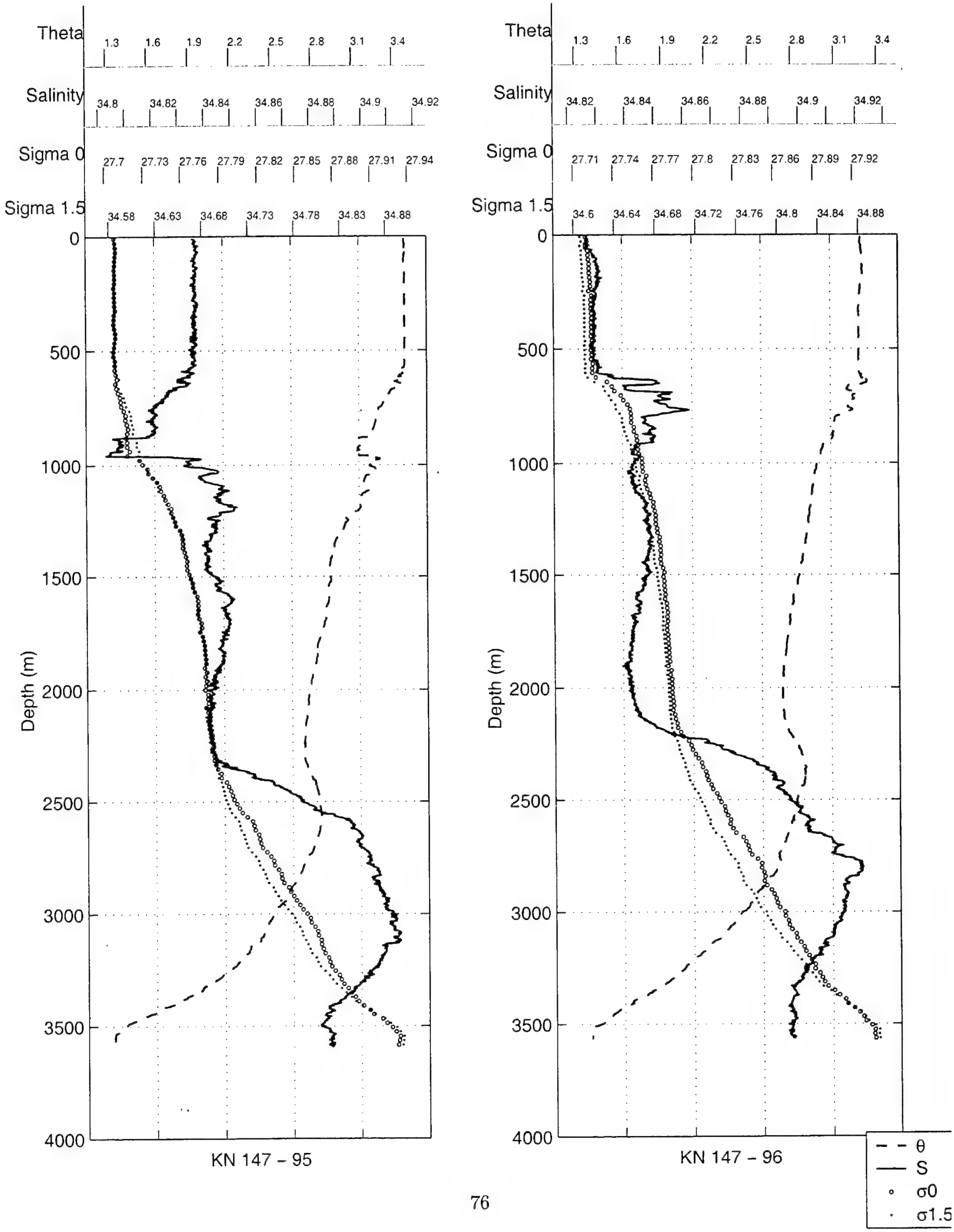


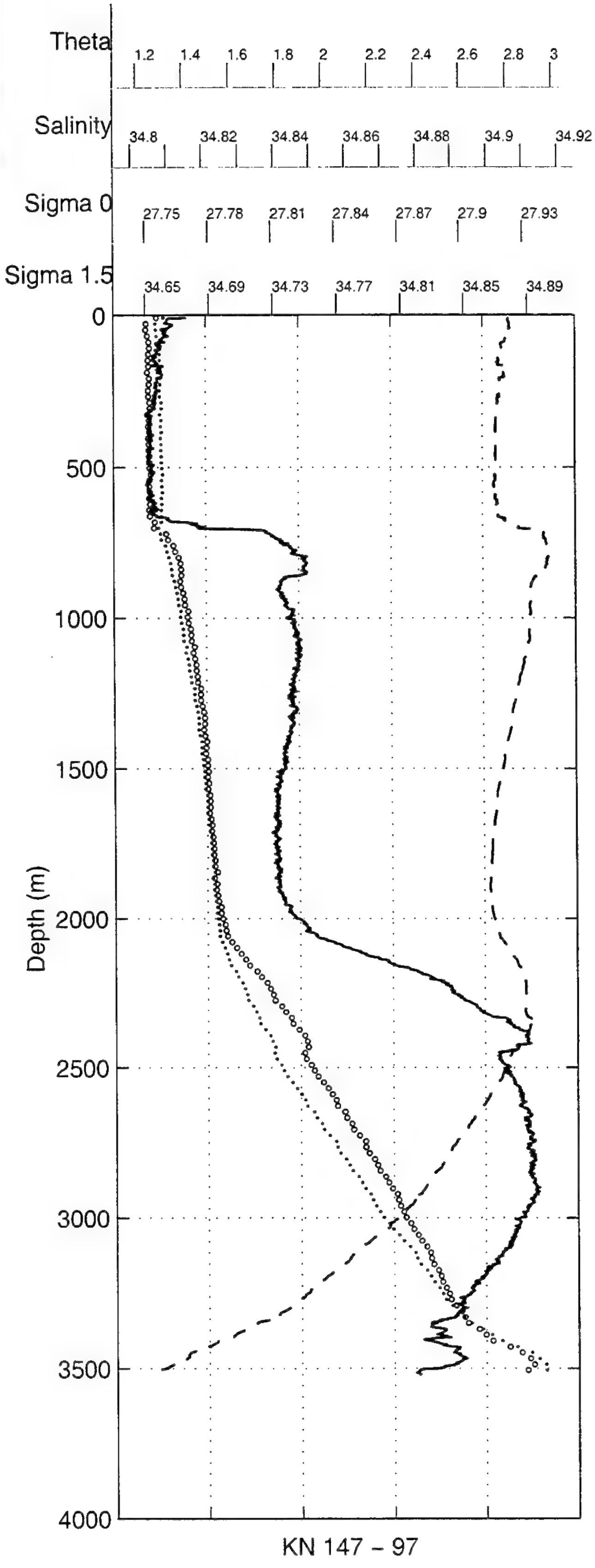
Theta
1.3
1.8
2.3
2.8
3.3
3.8
4.3
Salinity
34.2
34.3
34.4
34.5
34.6
34.7
34.8
34.9
35
Sigma 0
27.39
27.48
27.57
27.66
27.75
27.84
27.93
Sigma 1.5
34.36
34.44
34.52
34.6
34.68
34.76
34.84
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
KN 147 - 87
Theta
1.3
1.7
2.1
2.5
2.9
3.3
3.7
Salinity
34.38
34.46
34.54
34.62
34.7
34.78
34.86
Sigma 0
27.5
27.57
27.64
27.71
27.78
27.85
27.92
Sigma 1.5
34.47
34.54
34.61
34.68
34.75
34.82
34.89
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
KN 147 - 88
θ
S
σ0
σ1.5


Theta
1.3 1.7 2.1 2.5 2.9 3.3 3.7
Salinity
34.78 34.8 34.82 34.84 34.86 34.88 34.9 34.92
Sigma 0
27.67 27.71 27.75 27.79 27.83 27.87 27.91
Sigma 1.5
34.55 34.6 34.65 34.7 34.75 34.8 34.85 34.9
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 89
Theta
1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4
Salinity
34.82 34.84 34.86 34.88 34.9 34.92
Sigma 0
27.71 27.74 27.77 27.8 27.83 27.86 27.89 27.92
Sigma 1.5
34.6 34.65 34.7 34.75 34.8 34.85 34.9
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 90
θ
S
σ0
σ1.5

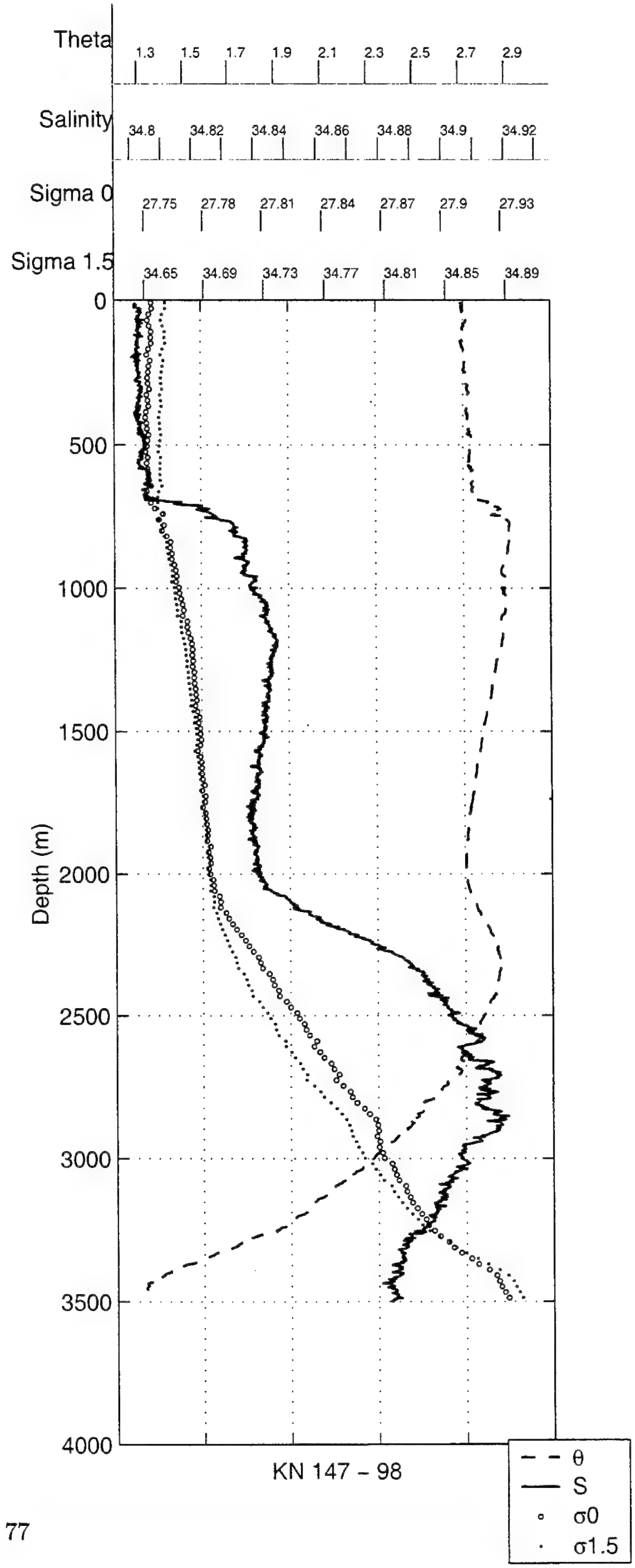

Theta
1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4
Salinity
34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.71 27.74 27.77 27.8 27.83 27.86 27.89 27.92
Sigma 1.5
34.59 34.63 34.67 34.71 34.75 34.79 34.83 34.87
Depth (m)
0 500 1000 1500 2000 2500 3000 3500 4000
KN 147 – 91
Theta
1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4
Salinity
34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.69 27.72 27.75 27.78 27.81 27.84 27.87 27.9 27.93
Sigma 1.5
34.57 34.62 34.67 34.72 34.77 34.82 34.87
Depth (m)
0 500 1000 1500 2000 2500 3000 3500 4000
KN 147 – 92
θ
S
σ0
σ1.5


Theta
1.3 1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9 3.1
Salinity
34.79 34.81 34.83 34.85 34.87 34.89 34.91 34.93
Sigma 0
27.73 27.76 27.79 27.82 27.85 27.88 27.91
Sigma 1.5
34.63 34.67 34.71 34.75 34.79 34.83 34.87
Depth (m)
0 500 1000 1500 2000 2500 3000 3500 4000
KN 147 - 93
Theta
1.2 1.5 1.8 2.1 2.4 2.7 3 3.3
Salinity
34.7 34.73 34.76 34.79 34.82 34.85 34.88 34.91
Sigma 0
27.69 27.73 27.77 27.81 27.85 27.89 27.93
Sigma 1.5
34.61 34.65 34.69 34.73 34.77 34.81 34.85 34.89
Depth (m)
0 500 1000 1500 2000 2500 3000 3500 4000
KN 147 - 94
θ
S
σ0
σ1.5

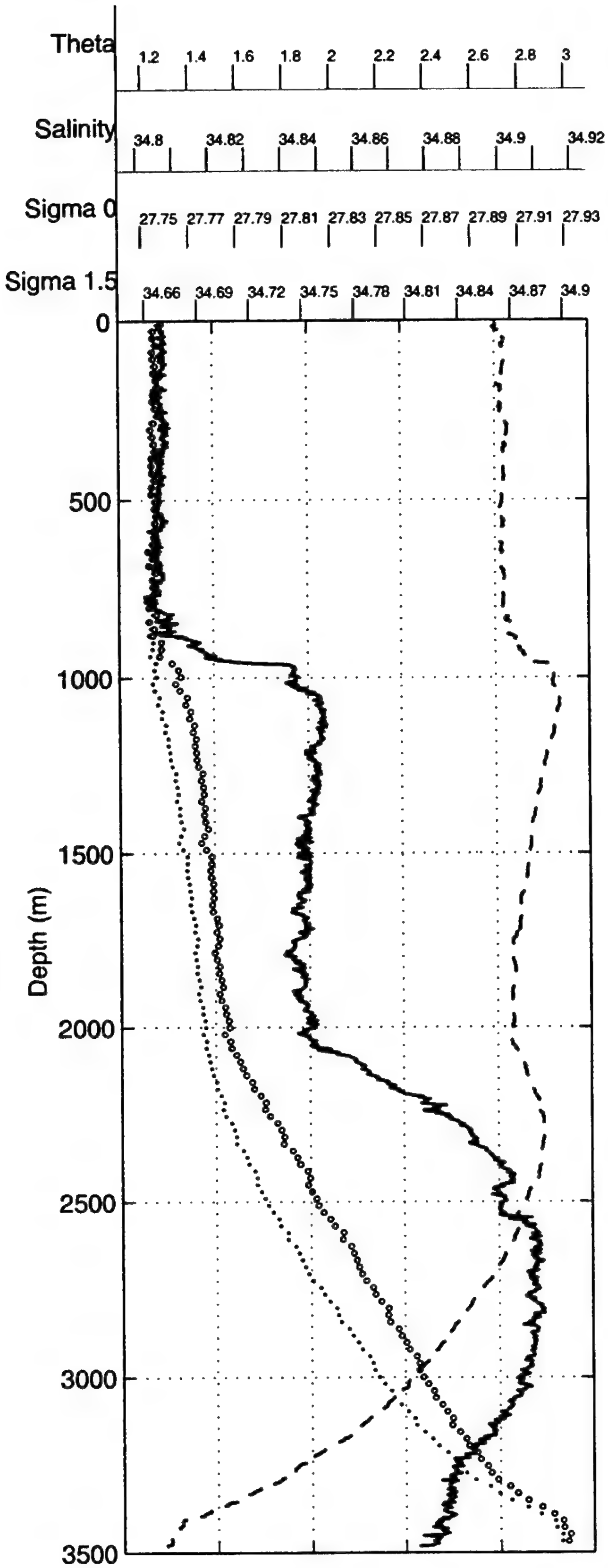

Theta
1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4
Salinity
34.8 34.82 34.84 34.86 34.88 34.9 34.92
Sigma 0
27.7 27.73 27.76 27.79 27.82 27.85 27.88 27.91 27.94
Sigma 1.5
34.58 34.63 34.68 34.73 34.78 34.83 34.88
Depth (m)
0 500 1000 1500 2000 2500 3000 3500 4000
KN 147 – 95
Theta
1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4
Salinity
34.82 34.84 34.86 34.88 34.9 34.92
Sigma 0
27.71 27.74 27.77 27.8 27.83 27.86 27.89 27.92
Sigma 1.5
34.6 34.64 34.68 34.72 34.76 34.8 34.84 34.88
Depth (m)
0 500 1000 1500 2000 2500 3000 3500 4000
KN 147 – 96
θ
S
σ0
σ1.5



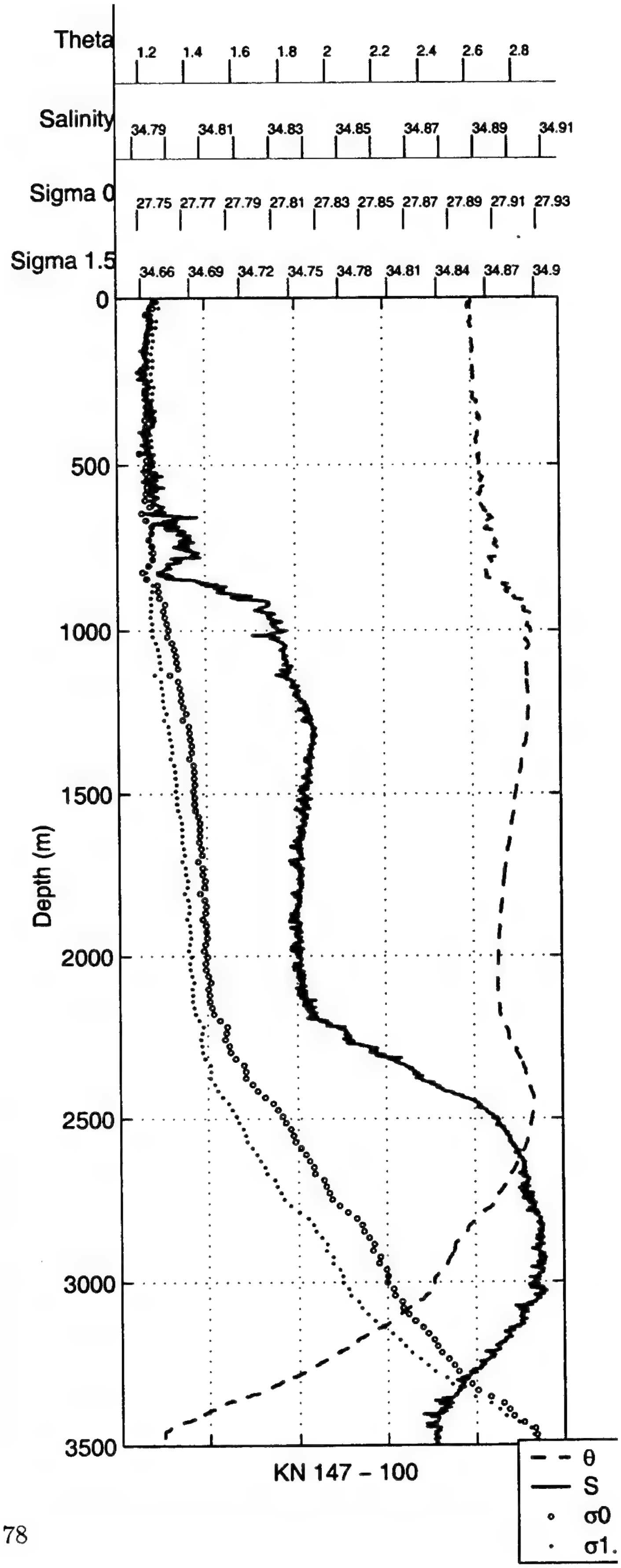
Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.8 34.82 34.84 34.86 34.88 34.9 34.92
Sigma 0
27.75 27.78 27.81 27.84 27.87 27.9 27.93
Sigma 1.5
34.65 34.69 34.73 34.77 34.81 34.85 34.89
Depth (m)
0 500 1000 1500 2000 2500 3000 3500 4000
KN 147 – 97



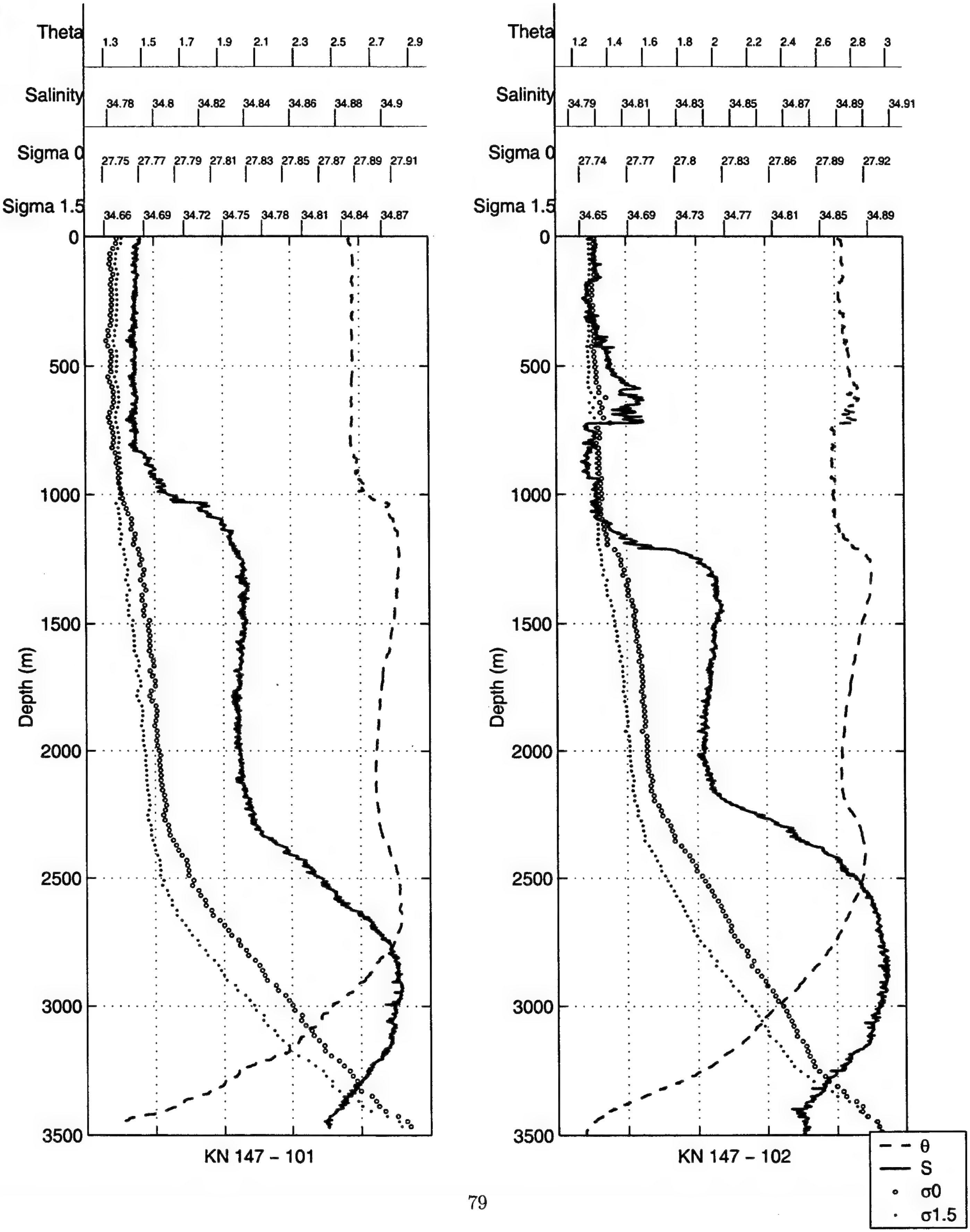
Theta
1.3 1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9
Salinity
34.8 34.82 34.84 34.86 34.88 34.9 34.92
Sigma 0
27.75 27.78 27.81 27.84 27.87 27.9 27.93
Sigma 1.5
34.65 34.69 34.73 34.77 34.81 34.85 34.89
Depth (m)
0 500 1000 1500 2000 2500 3000 3500 4000
KN 147 – 98
θ
S
σ0
σ1.5



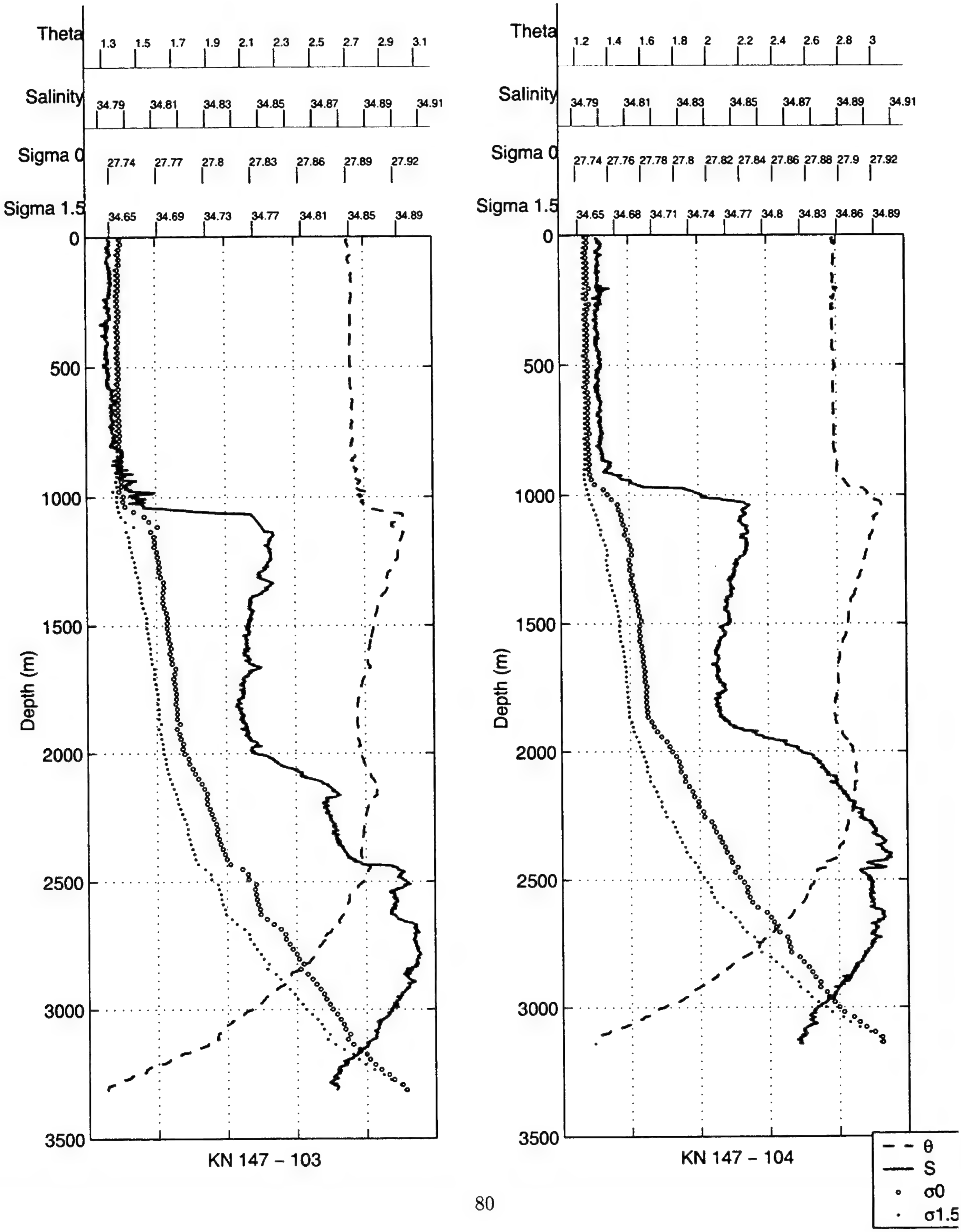
KN 147 – 99

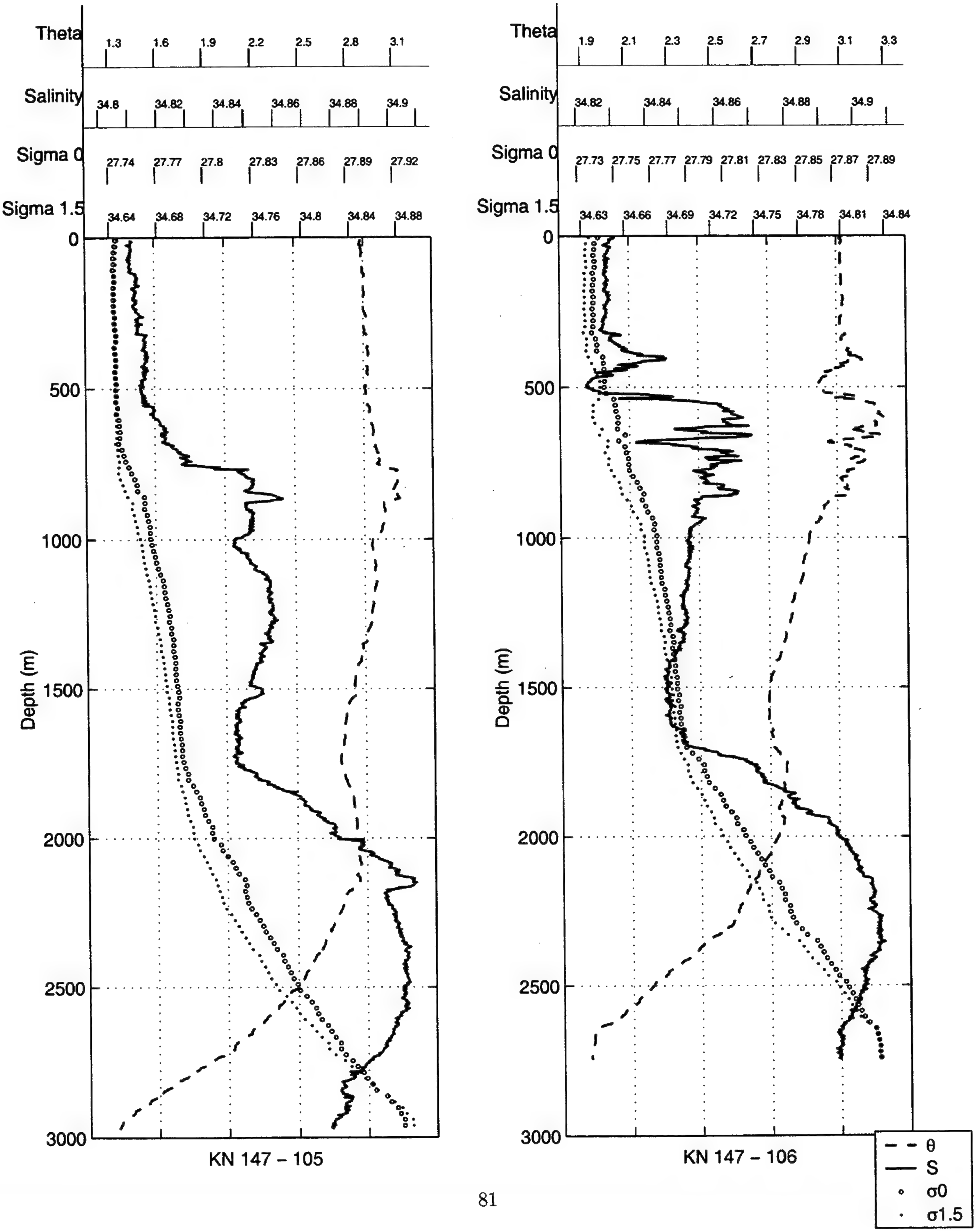


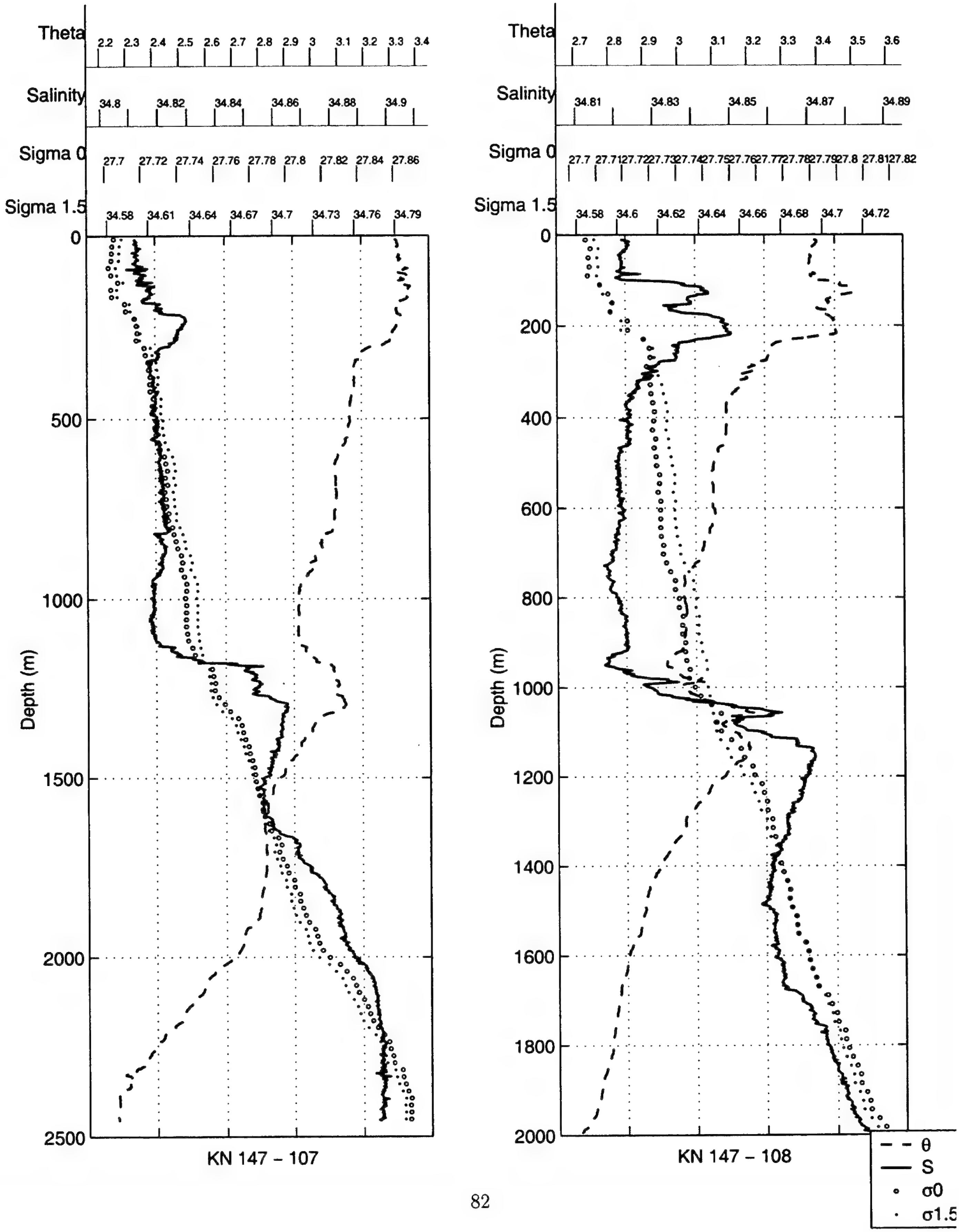
KN 147 – 100



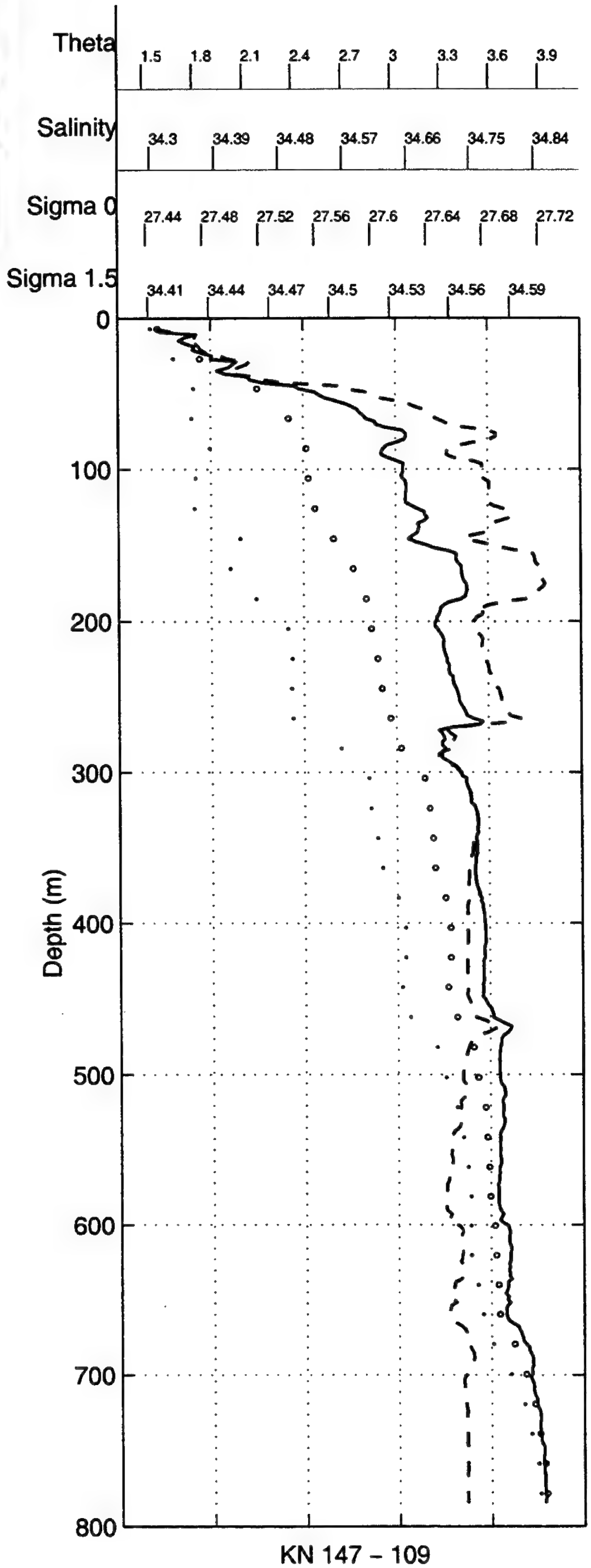
Theta
1.3 1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9
Salinity
34.78 34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.75 27.77 27.79 27.81 27.83 27.85 27.87 27.89 27.91
Sigma 1.5
34.66 34.69 34.72 34.75 34.78 34.81 34.84 34.87
0 500 1000 1500 2000 2500 3000 3500
Depth (m)
KN 147 - 101
Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.74 27.77 27.8 27.83 27.86 27.89 27.92
Sigma 1.5
34.65 34.69 34.73 34.77 34.81 34.85 34.89
0 500 1000 1500 2000 2500 3000 3500
Depth (m)
KN 147 - 102
θ
S
σ0
σ1.5

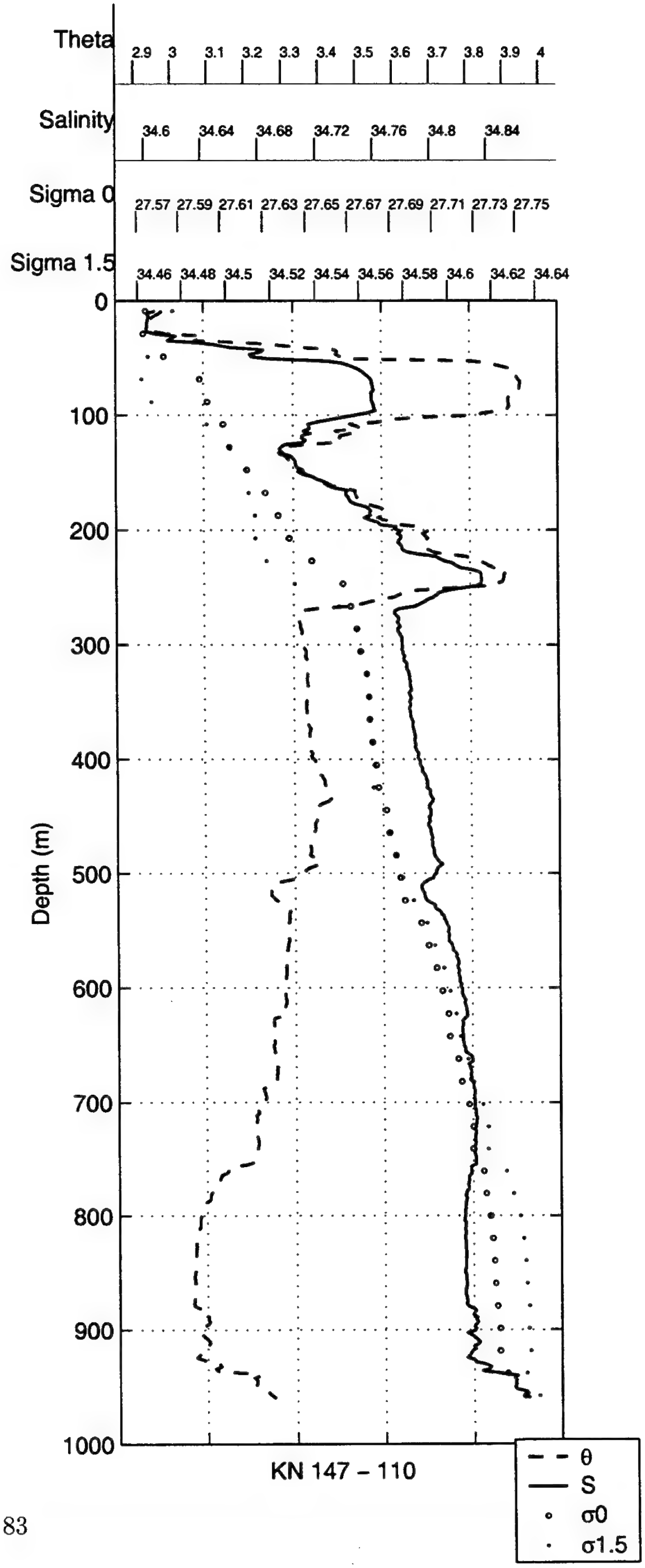

Theta
1.3 1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9 3.1
Salinity
34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.74 27.77 27.8 27.83 27.86 27.89 27.92
Sigma 1.5
34.65 34.69 34.73 34.77 34.81 34.85 34.89
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 103
Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.74 27.76 27.78 27.8 27.82 27.84 27.86 27.88 27.9 27.92
Sigma 1.5
34.65 34.68 34.71 34.74 34.77 34.8 34.83 34.86 34.89
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 – 104
θ
S
σ0
σ1.5

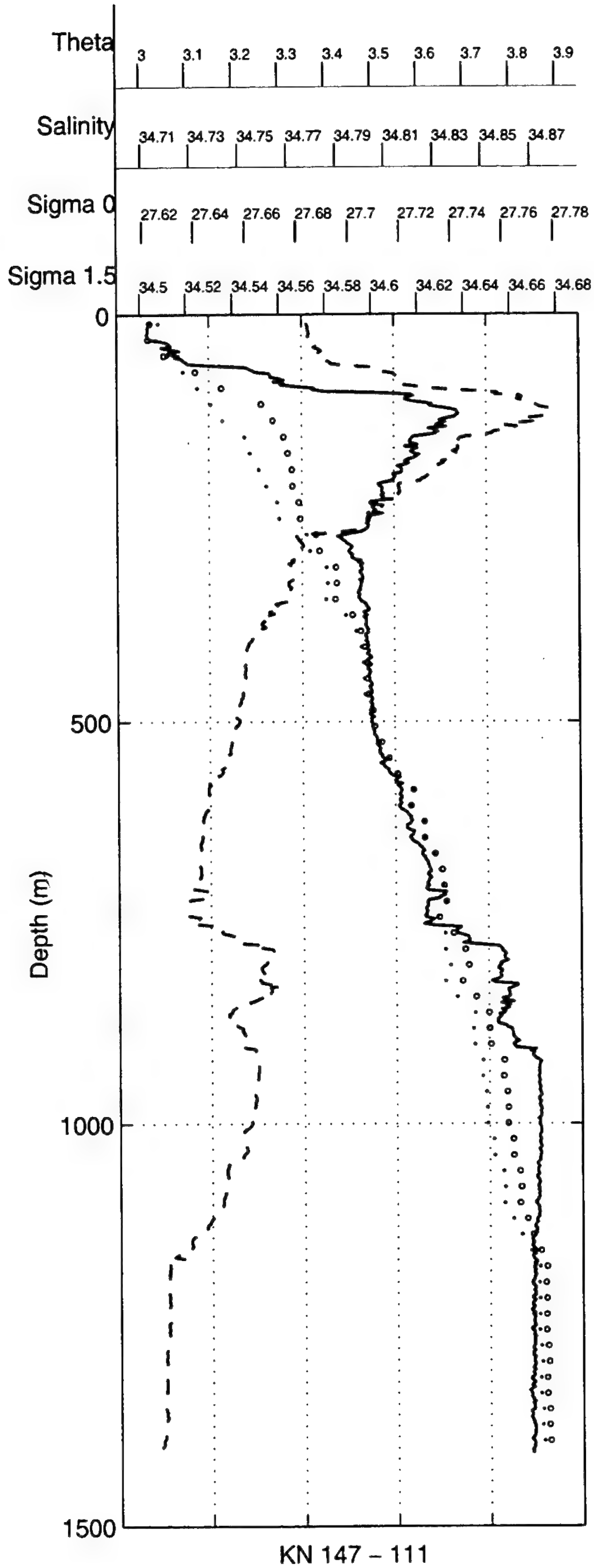

Theta
1.3 1.6 1.9 2.2 2.5 2.8 3.1
Salinity
34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.74 27.77 27.8 27.83 27.86 27.89 27.92
Sigma 1.5
34.64 34.68 34.72 34.76 34.8 34.84 34.88
Depth (m)
0 500 1000 1500 2000 2500 3000
KN 147 – 105
Theta
1.9 2.1 2.3 2.5 2.7 2.9 3.1 3.3
Salinity
34.82 34.84 34.86 34.88 34.9
Sigma 0
27.73 27.75 27.77 27.79 27.81 27.83 27.85 27.87 27.89
Sigma 1.5
34.63 34.66 34.69 34.72 34.75 34.78 34.81 34.84
Depth (m)
0 500 1000 1500 2000 2500 3000
KN 147 – 106
θ
S
σ0
σ1.5



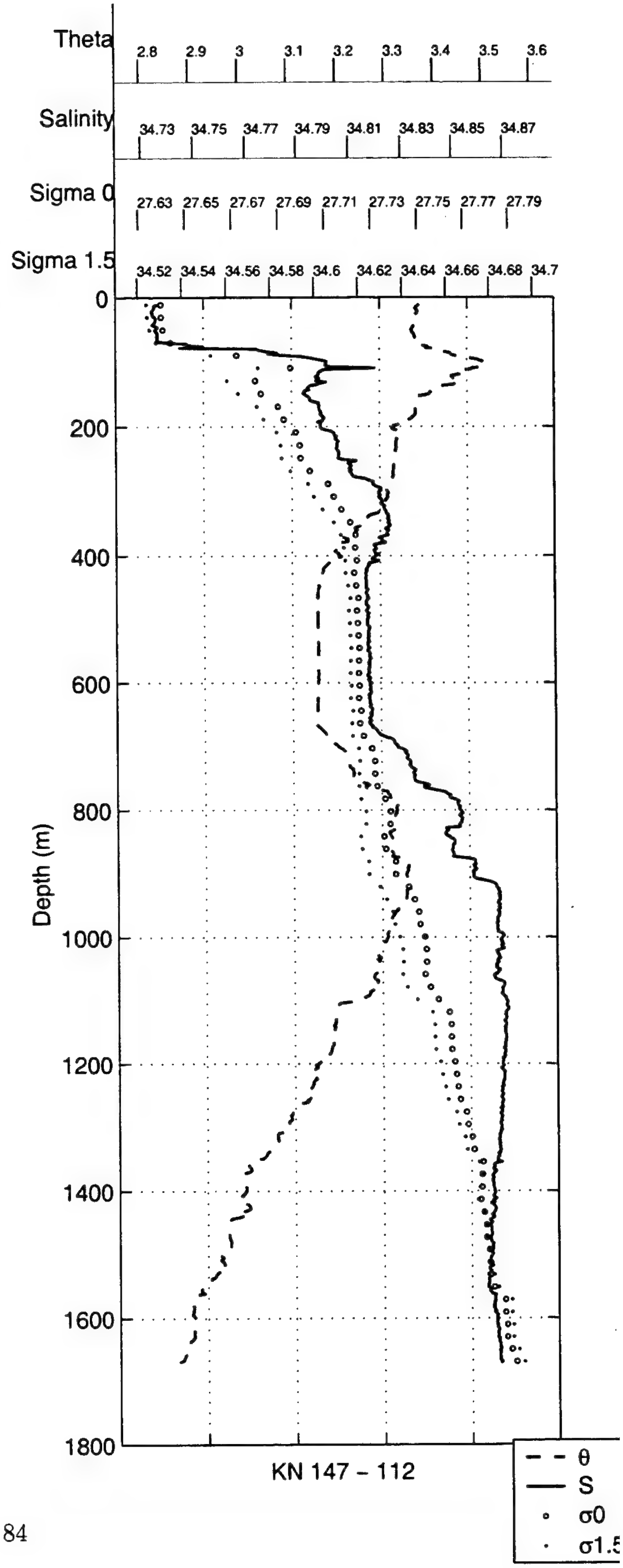
Theta
Salinity
Sigma 0
Sigma 1.5
Depth (m)
KN 147 - 107
KN 147 - 108
θ
S
σ0
σ1.5


Theta
1.5 1.8 2.1 2.4 2.7 3 3.3 3.6 3.9
Salinity
34.3 34.39 34.48 34.57 34.66 34.75 34.84
Sigma 0
27.44 27.48 27.52 27.56 27.6 27.64 27.68 27.72
Sigma 1.5
34.41 34.44 34.47 34.5 34.53 34.56 34.59
Depth (m)
0 100 200 300 400 500 600 700 800
KN 147 - 109

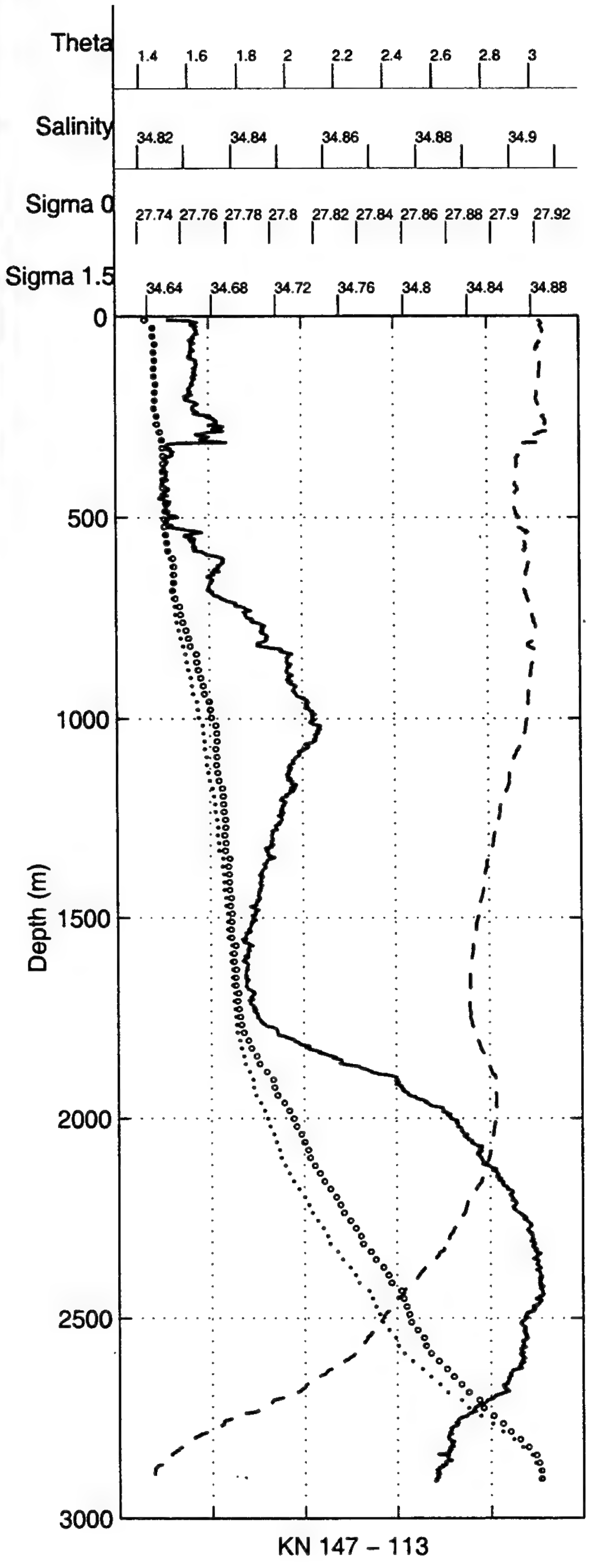

Theta
2.9 3 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9 4
Salinity
34.6 34.64 34.68 34.72 34.76 34.8 34.84
Sigma 0
27.57 27.59 27.61 27.63 27.65 27.67 27.69 27.71 27.73 27.75
Sigma 1.5
34.46 34.48 34.5 34.52 34.54 34.56 34.58 34.6 34.62 34.64
Depth (m)
0 100 200 300 400 500 600 700 800 900 1000
KN 147 - 110
θ
S
σ0
σ1.5



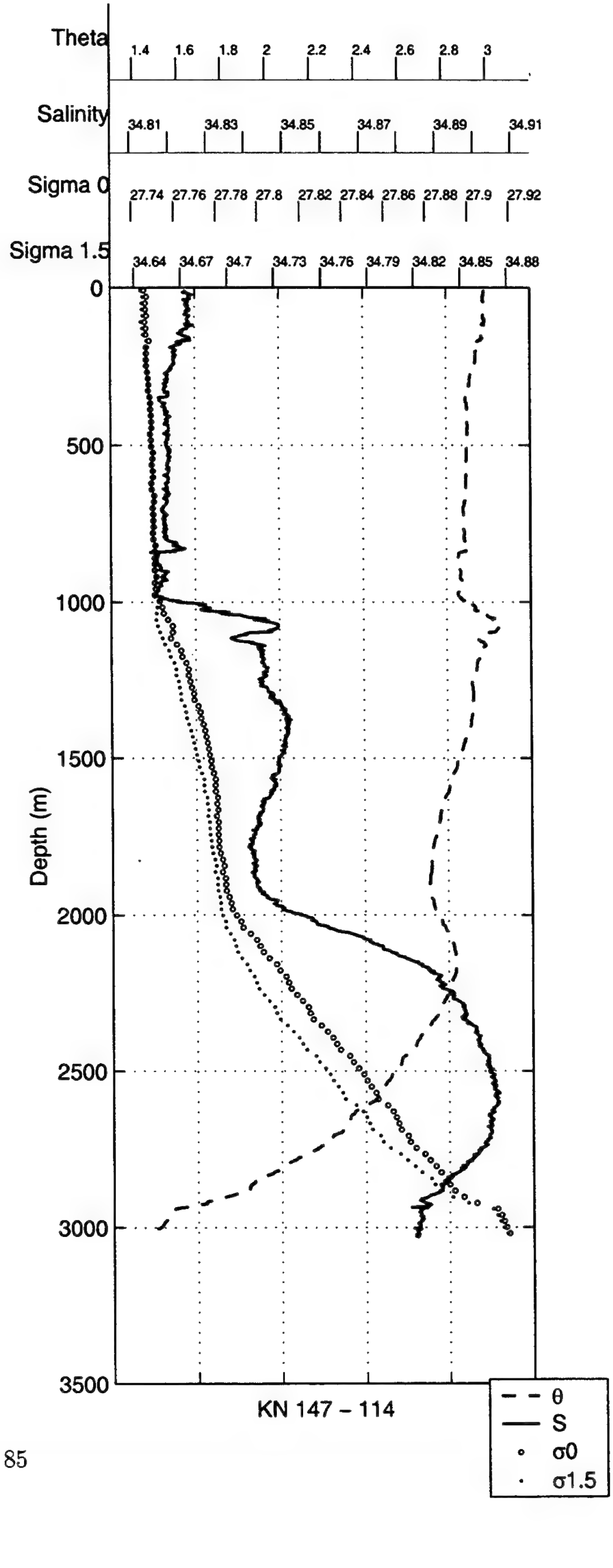
Theta
3 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9
Salinity
34.71 34.73 34.75 34.77 34.79 34.81 34.83 34.85 34.87
Sigma 0
27.62 27.64 27.66 27.68 27.7 27.72 27.74 27.76 27.78
Sigma 1.5
34.5 34.52 34.54 34.56 34.58 34.6 34.62 34.64 34.66 34.68
0
500
1000
1500
Depth (m)
KN 147 - 111



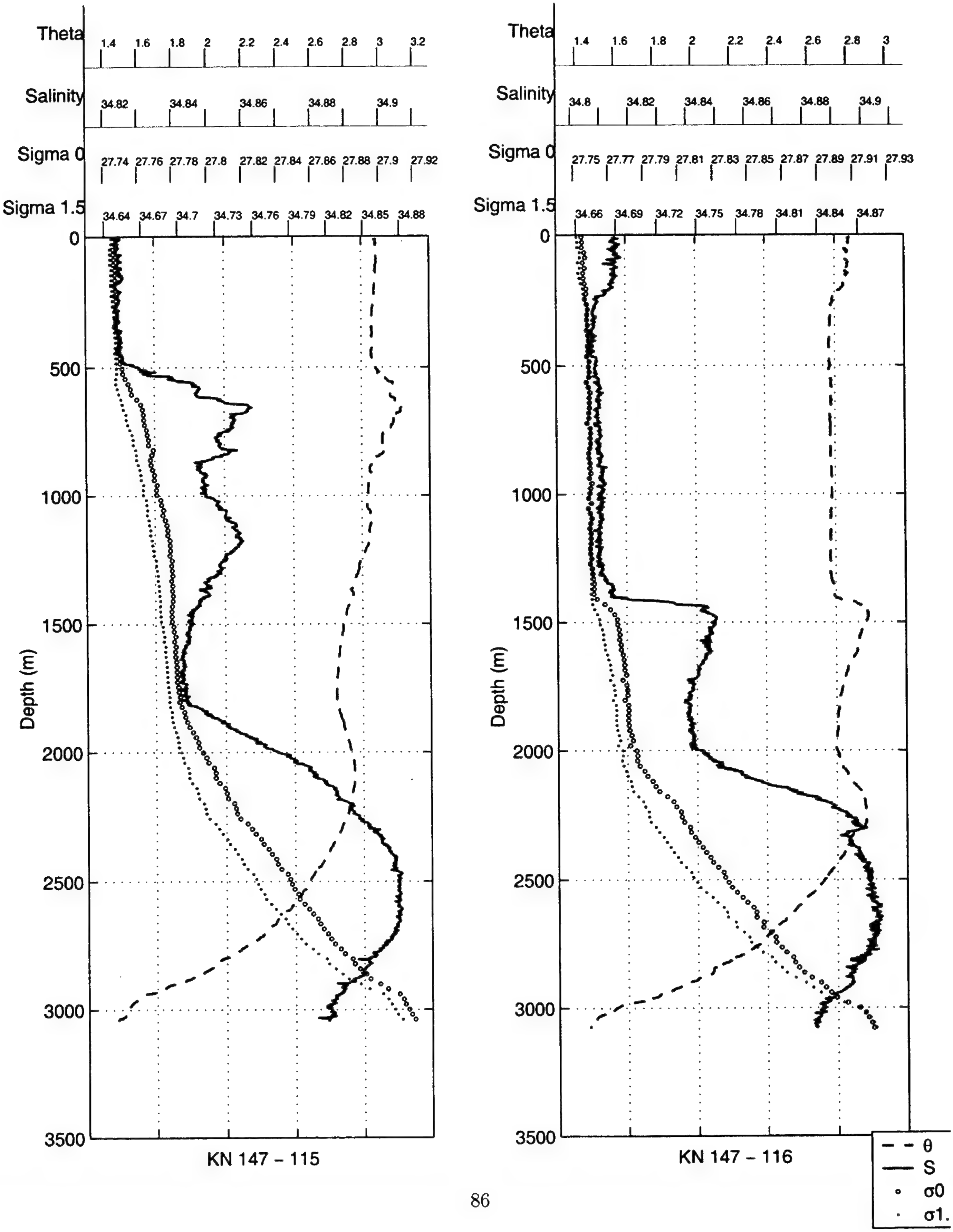
Theta
2.8 2.9 3 3.1 3.2 3.3 3.4 3.5 3.6
Salinity
34.73 34.75 34.77 34.79 34.81 34.83 34.85 34.87
Sigma 0
27.63 27.65 27.67 27.69 27.71 27.73 27.75 27.77 27.79
Sigma 1.5
34.52 34.54 34.56 34.58 34.6 34.62 34.64 34.66 34.68 34.7
0
200
400
600
800
1000
1200
1400
1600
1800
Depth (m)
KN 147 - 112
θ
S
σ0
σ1.5

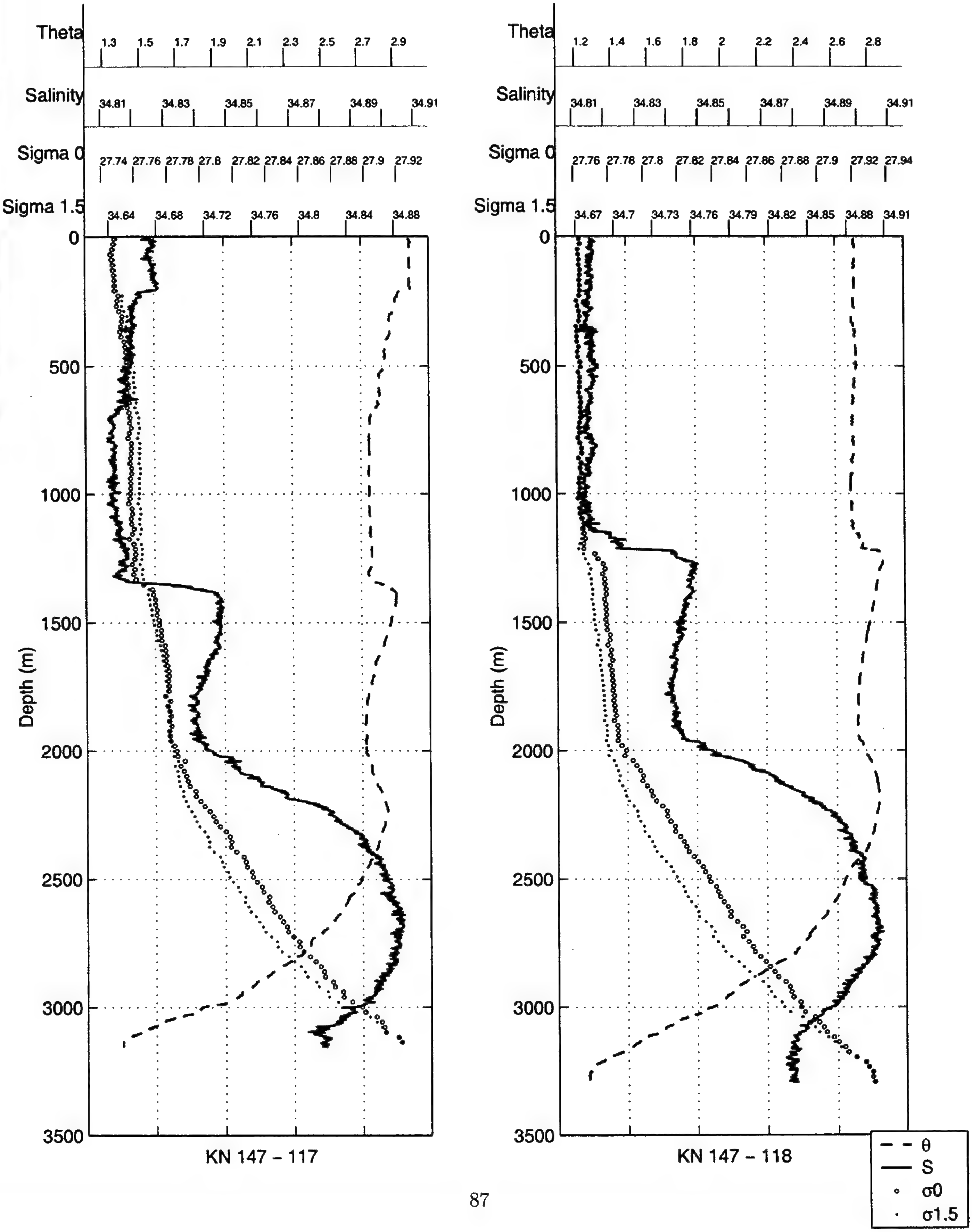


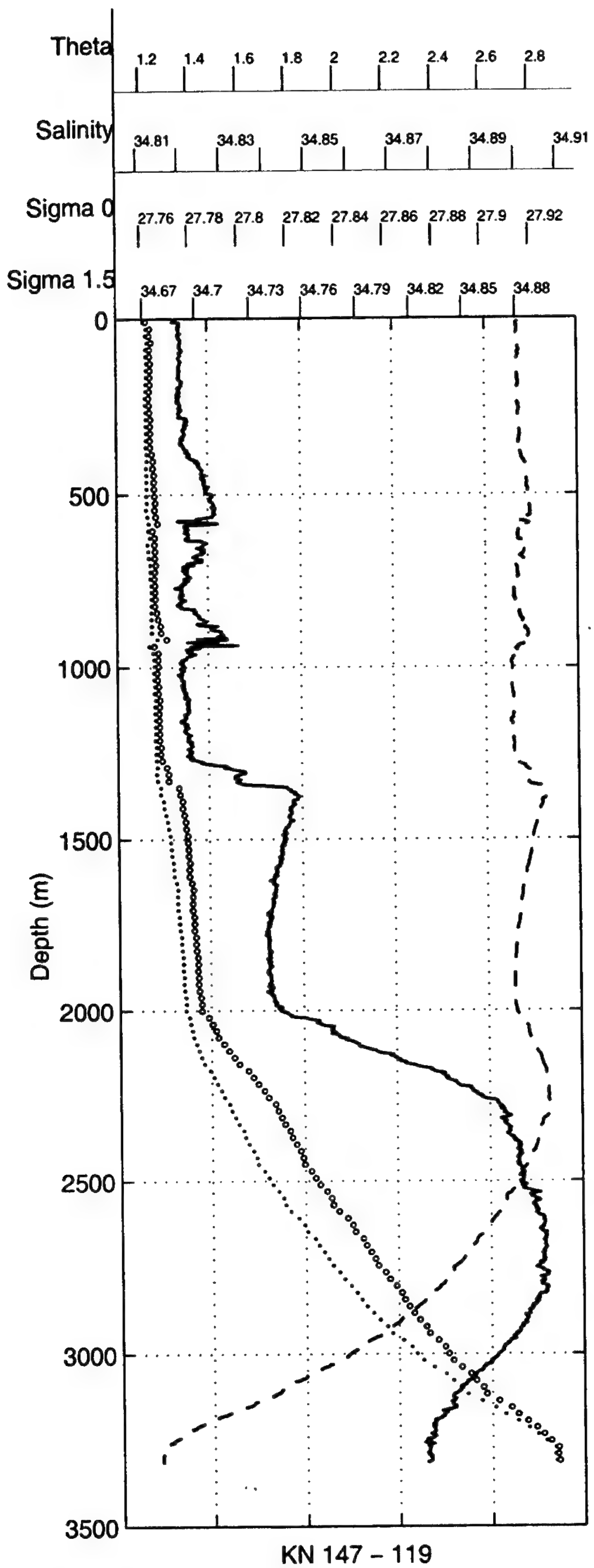
Theta
1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.82 34.84 34.86 34.88 34.9
Sigma 0
27.74 27.76 27.78 27.8 27.82 27.84 27.86 27.88 27.9 27.92
Sigma 1.5
34.64 34.68 34.72 34.76 34.8 34.84 34.88
Depth (m)
0 500 1000 1500 2000 2500 3000
KN 147 - 113

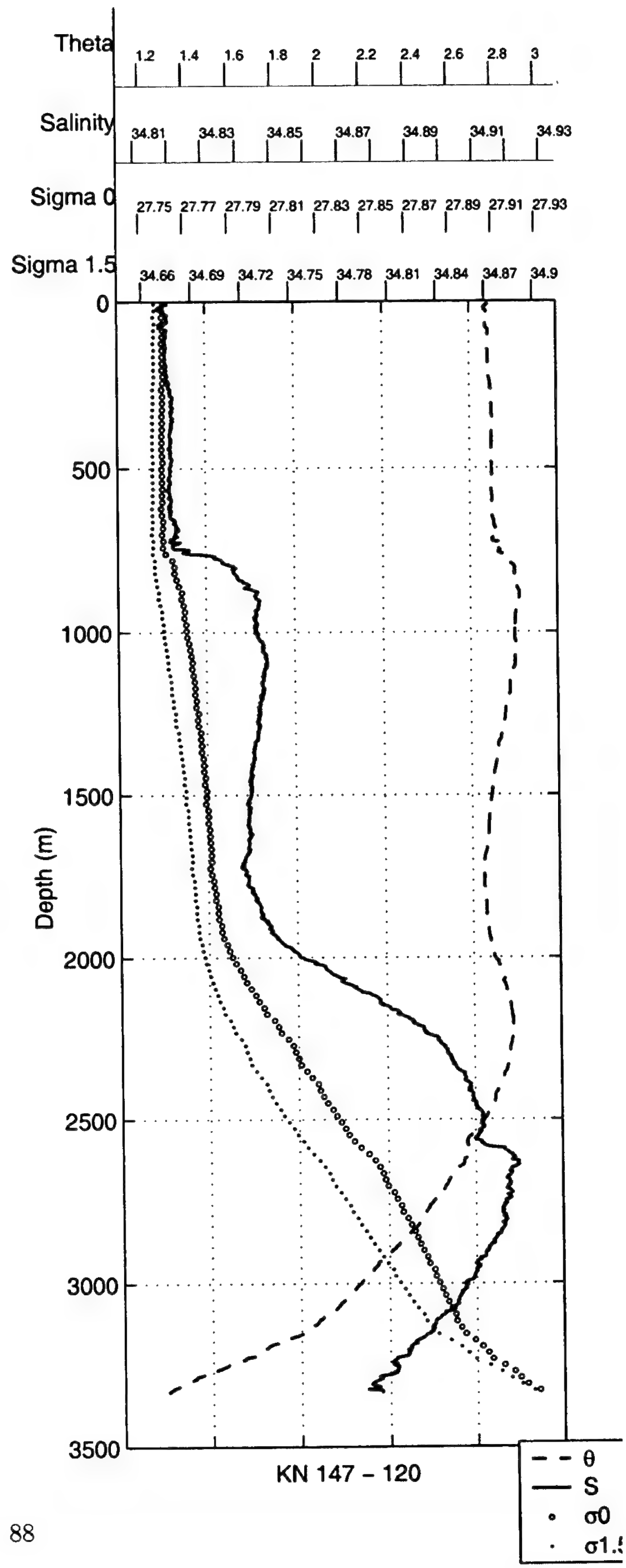


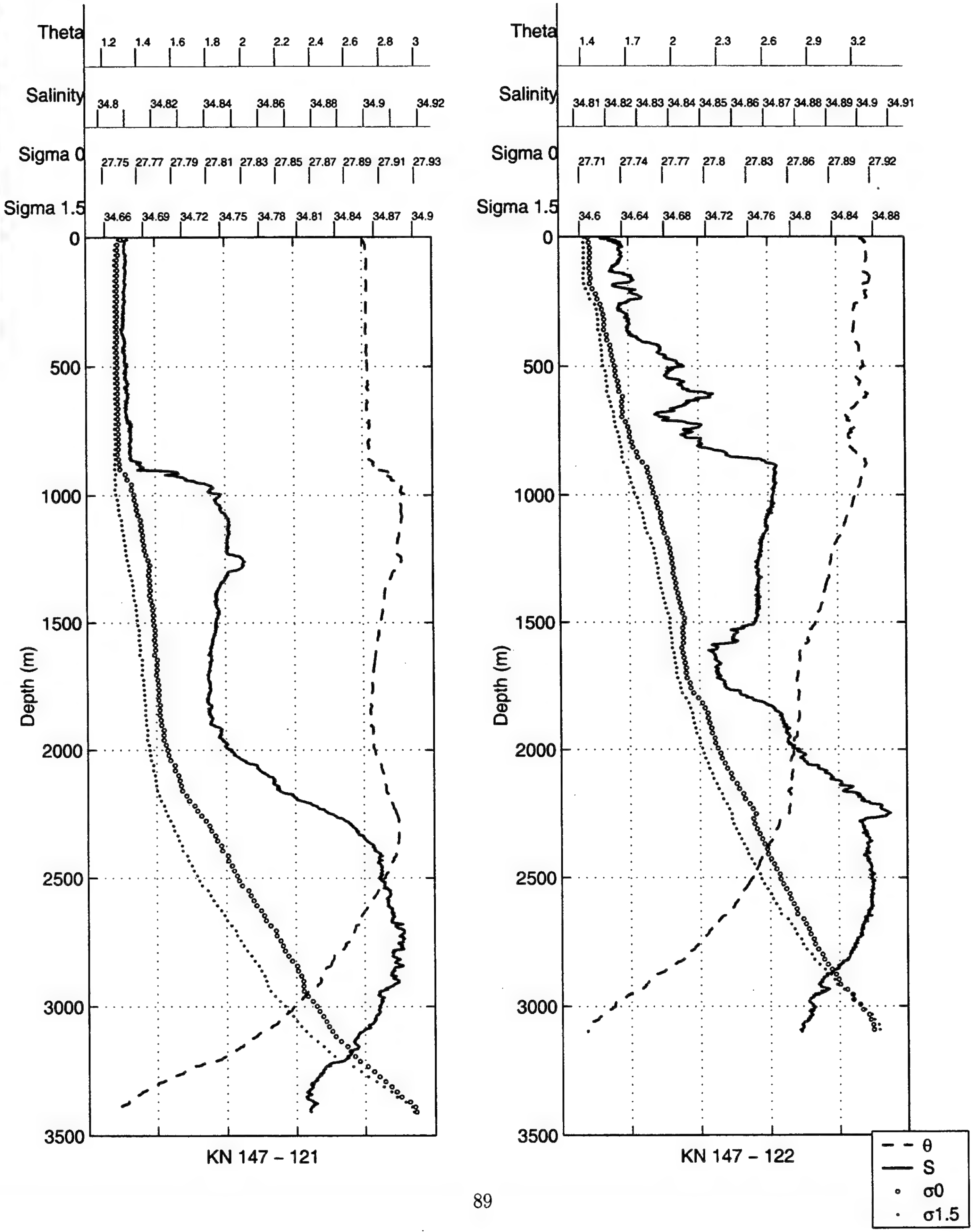
Theta
1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.74 27.76 27.78 27.8 27.82 27.84 27.86 27.88 27.9 27.92
Sigma 1.5
34.64 34.67 34.7 34.73 34.76 34.79 34.82 34.85 34.88
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 - 114
θ
S
σ0
σ1.5

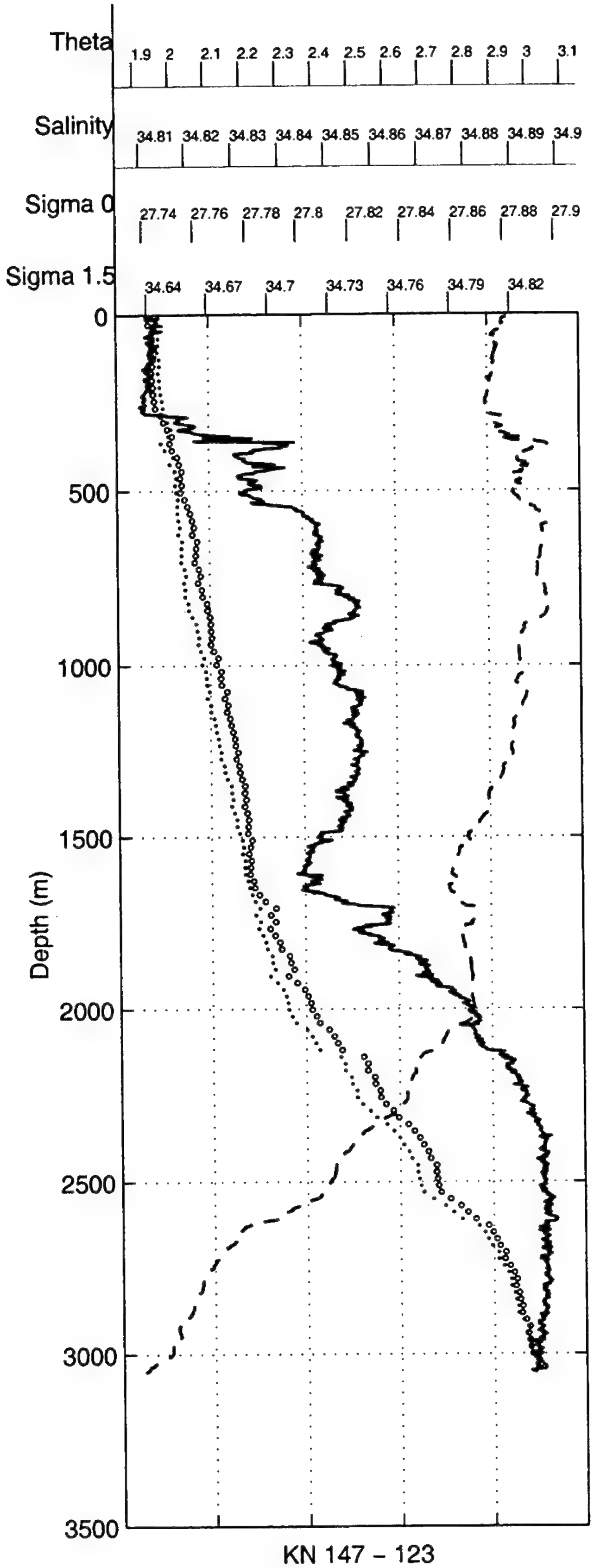

Theta
1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2
Salinity
34.82 34.84 34.86 34.88 34.9
Sigma 0
27.74 27.76 27.78 27.8 27.82 27.84 27.86 27.88 27.9 27.92
Sigma 1.5
34.64 34.67 34.7 34.73 34.76 34.79 34.82 34.85 34.88
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 - 115
Theta
1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.75 27.77 27.79 27.81 27.83 27.85 27.87 27.89 27.91 27.93
Sigma 1.5
34.66 34.69 34.72 34.75 34.78 34.81 34.84 34.87
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 - 116
θ
S
σ0
σ1.

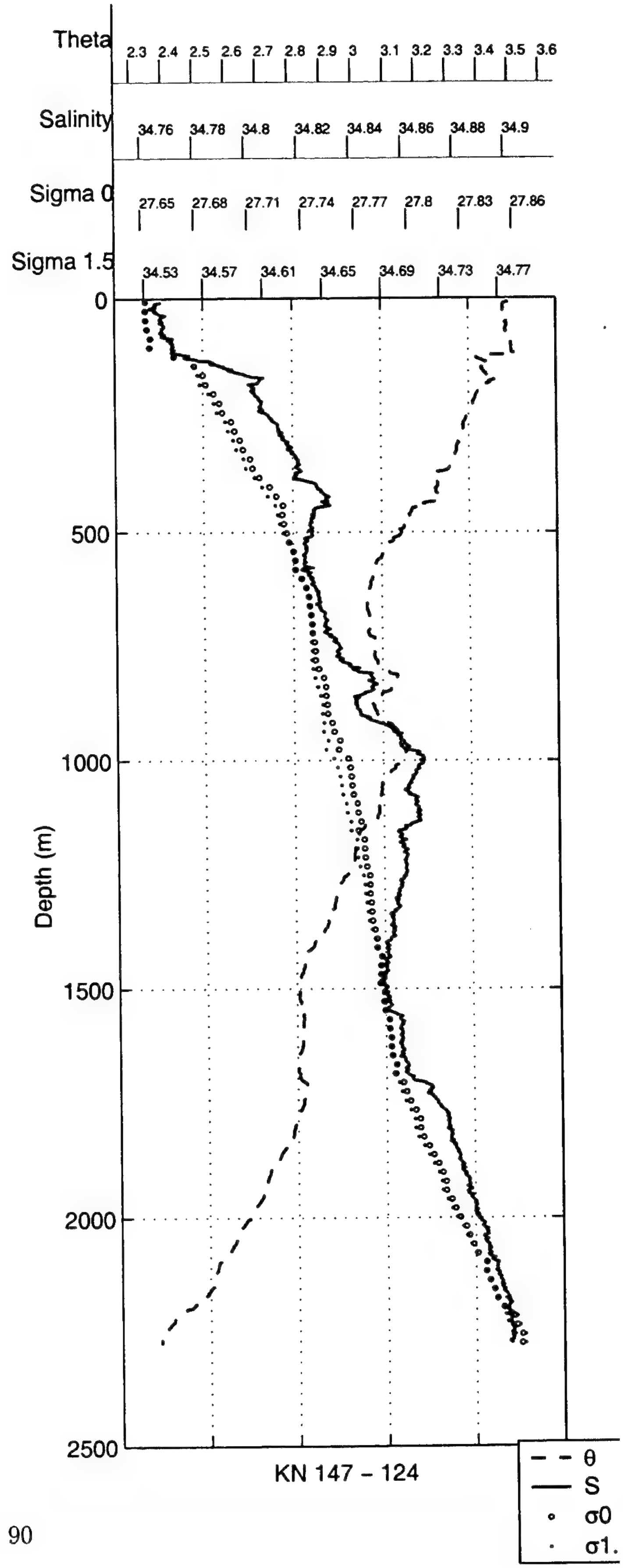

Theta
1.3 1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9
Salinity
34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.74 27.76 27.78 27.8 27.82 27.84 27.86 27.88 27.9 27.92
Sigma 1.5
34.64 34.68 34.72 34.76 34.8 34.84 34.88
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
KN 147 – 117
Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8
Salinity
34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.76 27.78 27.8 27.82 27.84 27.86 27.88 27.9 27.92 27.94
Sigma 1.5
34.67 34.7 34.73 34.76 34.79 34.82 34.85 34.88 34.91
Depth (m)
0
500
1000
1500
2000
2500
3000
3500
KN 147 – 118
θ
S
σ0
σ1.5

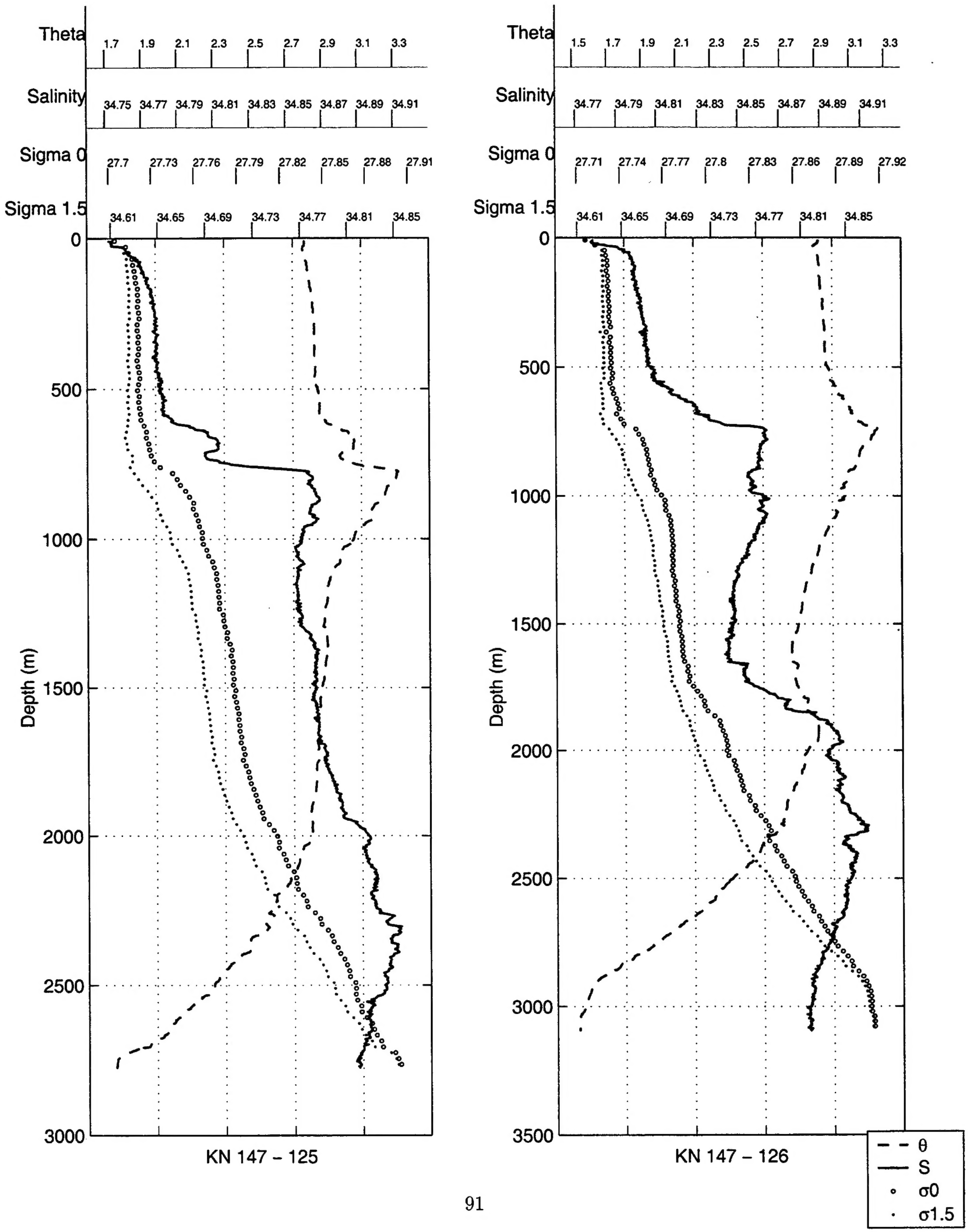

Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8
Salinity
34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.76 27.78 27.8 27.82 27.84 27.86 27.88 27.9 27.92
Sigma 1.5
34.67 34.7 34.73 34.76 34.79 34.82 34.85 34.88
0 500 1000 1500 2000 2500 3000 3500
Depth (m)
KN 147 – 119


Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.81 34.83 34.85 34.87 34.89 34.91 34.93
Sigma 0
27.75 27.77 27.79 27.81 27.83 27.85 27.87 27.89 27.91 27.93
Sigma 1.5
34.66 34.69 34.72 34.75 34.78 34.81 34.84 34.87 34.9
0 500 1000 1500 2000 2500 3000 3500
Depth (m)
KN 147 – 120
θ
S
σ0
σ1.5

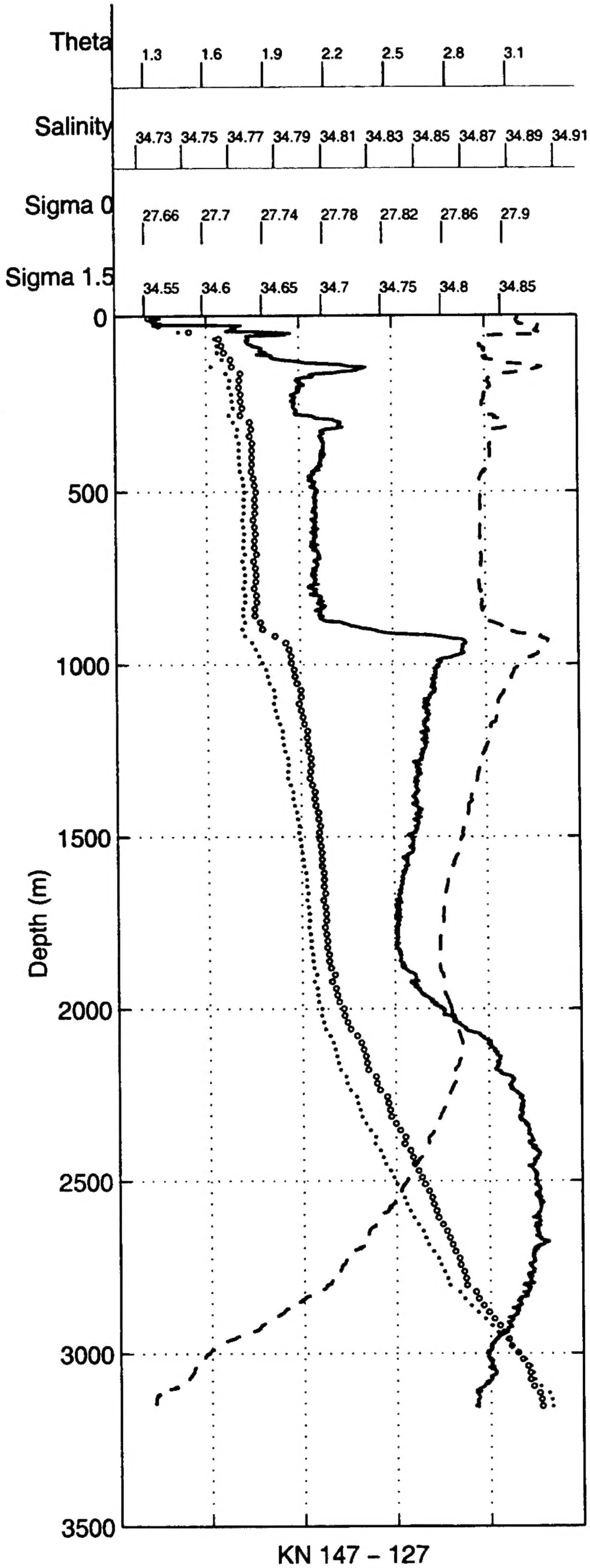

Theta
1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Salinity
34.8 34.82 34.84 34.86 34.88 34.9 34.92
Sigma 0
27.75 27.77 27.79 27.81 27.83 27.85 27.87 27.89 27.91 27.93
Sigma 1.5
34.66 34.69 34.72 34.75 34.78 34.81 34.84 34.87 34.9
0 500 1000 1500 2000 2500 3000 3500
Depth (m)
KN 147 - 121
Theta
1.4 1.7 2 2.3 2.6 2.9 3.2
Salinity
34.81 34.82 34.83 34.84 34.85 34.86 34.87 34.88 34.89 34.9 34.91
Sigma 0
27.71 27.74 27.77 27.8 27.83 27.86 27.89 27.92
Sigma 1.5
34.6 34.64 34.68 34.72 34.76 34.8 34.84 34.88
0 500 1000 1500 2000 2500 3000 3500
Depth (m)
KN 147 - 122
θ
S
σ0
σ1.5


Theta
1.9 2 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3 3.1
Salinity
34.81 34.82 34.83 34.84 34.85 34.86 34.87 34.88 34.89 34.9
Sigma 0
27.74 27.76 27.78 27.8 27.82 27.84 27.86 27.88 27.9
Sigma 1.5
34.64 34.67 34.7 34.73 34.76 34.79 34.82
0
500
1000
1500
2000
2500
3000
3500
Depth (m)
KN 147 – 123


Theta
2.3 2.4 2.5 2.6 2.7 2.8 2.9 3 3.1 3.2 3.3 3.4 3.5 3.6
Salinity
34.76 34.78 34.8 34.82 34.84 34.86 34.88 34.9
Sigma 0
27.65 27.68 27.71 27.74 27.77 27.8 27.83 27.86
Sigma 1.5
34.53 34.57 34.61 34.65 34.69 34.73 34.77
0
500
1000
1500
2000
2500
Depth (m)
KN 147 – 124
θ
S
σ0
σ1.



Theta
1.7 1.9 2.1 2.3 2.5 2.7 2.9 3.1 3.3
Salinity
34.75 34.77 34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.7 27.73 27.76 27.79 27.82 27.85 27.88 27.91
Sigma 1.5
34.61 34.65 34.69 34.73 34.77 34.81 34.85
Depth (m)
0 500 1000 1500 2000 2500 3000
KN 147 - 125
Theta
1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9 3.1 3.3
Salinity
34.77 34.79 34.81 34.83 34.85 34.87 34.89 34.91
Sigma 0
27.71 27.74 27.77 27.8 27.83 27.86 27.89 27.92
Sigma 1.5
34.61 34.65 34.69 34.73 34.77 34.81 34.85
Depth (m)
0 500 1000 1500 2000 2500 3000 3500
KN 147 - 126
θ
S
σ0
σ1.5



Theta
1.3
1.6
1.9
2.2
2.5
2.8
3.1
Salinity
34.73
34.75
34.77
34.79
34.81
34.83
34.85
34.87
34.89
34.91
Sigma 0
27.66
27.7
27.74
27.78
27.82
27.86
27.9
Sigma 1.5
34.55
34.6
34.65
34.7
34.75
34.8
34.85
0
500
1000
1500
2000
2500
3000
3500
Depth (m)
KN 147 - 127

DOCUMENT LIBRARY

Distribution List for Technical Report Exchange – July 1998

University of California, San Diego
SIO Library 0175C
9500 Gilman Drive
La Jolla, CA 92093-0175

Hancock Library of Biology & Oceanography
Alan Hancock Laboratory
University of Southern California
University Park
Los Angeles, CA 90089-0371

Gifts & Exchanges
Library
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, NS, B2Y 4A2, CANADA

NOAA/EDIS Miami Library Center
4301 Rickenbacker Causeway
Miami, FL 33149

Research Library
U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Marine Resources Information Center
Building E38-320
MIT
Cambridge, MA 02139

Library
Lamont-Doherty Geological Observatory
Columbia University
Palisades, NY 10964

Library
Serials Department
Oregon State University
Corvallis, OR 97331

Pell Marine Science Library
University of Rhode Island
Narragansett Bay Campus
Narragansett, RI 02882

Working Collection
Texas A&M University
Dept. of Oceanography
College Station, TX 77843

Fisheries-Oceanography Library
151 Oceanography Teaching Bldg.
University of Washington
Seattle, WA 98195

Library
R.S.M.A.S.
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149

Maury Oceanographic Library
Naval Oceanographic Office
Building 1003 South
1002 Balch Blvd.
Stennis Space Center, MS, 39522-5001

Library
Institute of Ocean Sciences
P.O. Box 6000
Sidney, B.C. V8L 4B2
CANADA

National Oceanographic Library
Southampton Oceanography Centre
European Way
Southampton SO14 3ZH
UK

The Librarian
CSIRO Marine Laboratories
G.P.O. Box 1538
Hobart, Tasmania
AUSTRALIA 7001

Library
Proudman Oceanographic Laboratory
Bidston Observatory
Birkenhead
Merseyside L43 7 RA
UNITED KINGDOM

IFREMER
Centre de Brest
Service Documentation - Publications
BP 70 29280 PLOUZANE
FRANCE

0272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. WHOI-2000-05	2.	3. Recipient's Accession No.
4. Title and Subtitle *Knorr* 147 Leg V Hydrographic Data Report: Labrador Sea Deep Convection Experiment			5. Report Date May 2000
			6.
7. Author(s) Sarah Zimmerman, Theresa K. McKee, Robert S. Pickart, William M. Smethie			8. Performing Organization Rept. No. WHOI-2000-05
9. Performing Organization Name and Address Woods Hole Oceanographic Institution Woods Hole, Massachusetts 02543			10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) N00014-97-1-0043 (G)
12. Sponsoring Organization Name and Address Office of Naval Research			13. Type of Report & Period Covered Technical Report
			14.

15. Supplementary Notes

This report should be cited as: Woods Hole Oceanog. Inst. Tech. Rept., WHOI-2000-05.

16. Abstract (Limit: 200 words)

Between 2 February and 20 March 1997, the first phase of the Labrador Sea Deep Convection Experiment was carried out on R/V *Knorr*, during which 127 hydrographic stations were occupied throughout the Labrador basin. This included five boundary crossings (two on the east and three on the west.) Special emphasis was placed on the western portion of the basin where deep convection occurs. Expendable Bathy Thermographs (XBTs) were launched regularly to increase resolution near the boundary and to help optimally place interior stations. Three "to-yo" CTD surveys were conducted, and Langrangian floats were deployed throughout the cruise. Despite extremely difficult working conditions, the cruise was successful in observing deep convection under "classic" wintertime conditions. This report describes the CTD operation and performance and also presents vertical profiles of CTD Potential Temperature, Salinity, and Potential Density (referenced to the surface and 1500 db) plotted versus Depth. Instructions for obtaining the data via anonymous FTP are included in Appendix B.

17. Document Analysis a. Descriptors

Deep Convection
Labrador Sea
Wintertime Circulation

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Approved for public release; distribution unlimited.	UNCLASSIFIED	98
	20. Security Class (This Page)	22. Price

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce